CANADA

DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

MEMOIR 65

No. 53, GEOLOGICAL SERIES

Clay and Shale Deposits of the Western Provinces

(PART IV)

BY

H. Ries

MEMOIR 66

No. 54, GEOLOGICAL SERIES

Clay and Shale Deposits of the Western Provinces

(PART V)

BY

J. Keele

OTTAWA
GOVERNMENT PRINTING BUREAU
1915

Nos. 1453 and 1455

CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.
GEOLOGICAL SURVEY

MEMOIR 65

No. 53, GEOLOGICAL SERIES

Clay and Shale Deposits of the Western Provinces

(PART IV)

BY
H. Ries

OTTAWA
GOVERNMENT PRINTING BUREAU
1915

1453

CONTENTS.

ILLUSTRATIONS.

Clay and Shale Deposits of the Western Provinces.

PART IV.

INTRODUCTORY.

In the three reports already published on the clay and shale resources of the western provinces, the plastic materials occurring in the different geologic formations have been discussed in some detail, and many tests given. It cannot be assumed that with these four reports the last work on western clays will have been printed, for in no case during the work has it been deemed practicable to go many miles from the railway, as clay will not stand long hauls. There are in the west many hundreds of square miles of territory, which have not yet been made accessible by the railways, but in which there are no doubt important clay deposits still to be found. This is perhaps more true of the mountainous region lying between the Great Plains and the Pacific coast. The great forested area of central and northern Vancouver island is also likely to yield some plastic materials of commercial importance.

The present report does not aim to cover a large number of localities, but refers to some of those which it was not possible to visit in other seasons. In addition a very few were revisited for the purpose of obtaining some additional information. The important localities, included in the field season of 1913, were: Blue mountain near Whonnock, B.C.; the Nanaimo district, B.C.; Princeton, B.C.; Wyckliffe, B.C.; Cranbrook, B.C.; Creston, B.C.; Kilgard, B.C.; Blairmore and Coleman, Alberta; Passburg, Alberta; South Fork, Alberta.

BLUE MOUNTAIN, B.C.

This mountain contains one of the strongest shale deposits thus far discovered in the province of British Columbia, and ranks next to Sumas mountain.

Blue mountain is situated about 4 miles north of Whonnock on the Canadian Pacific railway. The gentle slopes of the mountain are heavily wooded, and show practically no outcrops, until an elevation, said to be 2,500 feet, is reached. Above this in several steep ravines there are a number of exposures of shale on the property of the Blue Mountain Refractories Company, Ltd., of Vancouver. The claims are in sec. 2, in both the NE. and NW. $\frac{1}{4}$ sec. in tp. 4, range 4, W. 7th mer., in the New Westminster district.

The general section of sedimentary beds consists of sandstones, sandy shales, and fine-grained conglomerate, which rest in turn on granitic rocks of the Coast Range batholith. No opinion is ventured here regarding the age of these stratified rocks, except to state that they are probably not a portion of the Eocene delta deposits of the Fraser river as these do not reach the elevation.[1]

The best section seen was exposed in a ravine which is tributary to that of Gold stream, and must be at least 250 feet thick, the lower 150 feet being largely red shale, with a conchoidal fracture. The underlying rock, the granite, appears to be rather uneven, for while the shales extend down the tributary to its junction with Gold stream, on the latter they are first found at least 100 feet higher.

At the juncture of the main stream and its tributary there is a heavy bed of red shale, with an exposed face at least 25 feet high. It is indistinctly stratified, and breaks into irregular pieces. This red shale is also found outcropping up the ravine of Gold stream, but here it is underlain by a coarse conglomerate consisting of boulders of igneous rock from 1 to 2 feet in diameter, and which in turn overlie the granitic rock.

Above the red shale there is a blue shale, and similar material is found outcropping up the tributary ravine near an old tunnel.

---

[1]Inter. Geol. Congress, Guide Book No. 8, Part III, p. 271, 1913.

Before referring to the properties of the shale a further statement should be made regarding its location. The material outcrops on the south side of Blue mountain at an altitude of about 2,500 feet, and about 7 miles from the Fraser river at Whonnock. It is out of the question to locate the plant at the deposit, and, therefore, the shale would have to be brought down to the plant which could be placed near the river and railway. For transporting the raw material, an aërial tram would probably serve best and there seem no obstacles to the installation of such a method of transportation.

The method of working the deposit should also be carefully considered. Where the best exposures occur the mountain slope is steep, and the shale would have to be worked by underground methods, but if the deposit is of any great extent, the possibility exists that it could be found at other points on the mountain side, where the slope was less steep, and hence a certain amount of open-cut mining could be carried on.

The samples tested were five in number, and their properties are given below.

Red Shale (*Lab. No. 1942*).

This represents the bright red shale found at the junction of the two creeks. It is smooth and dense, but when ground dry and then mixed with water has fair working qualities, although its plasticity is not very high, and it did not flow well through an annular die. I believe that tempering in a wet pan would greatly improve its plasticity.

It took 18 per cent of water to work it up to a plastic mass, whose air shrinkage was 5 per cent, and average tensile strength when air dried, 25 pounds per square inch.

This plastic mixture was formed into test bricklets which were fired at seven different cones, with the results tabulated following:

Laboratory Sample No. 1942.

Cone	Fire shrinkage %	Absorption %
010	1	17·20
05	2	16·07
1	3	13·63
3	4	6·90
5	5	1·28
7	Past vitrification	
9	Viscous	

Reference to these figures and their graphic representation in Figure 1, shows that the shale has a low fire shrinkage, but that the absorption while moderate up to cone 1, drops rapidly after that.

The shale burns to a good red brick which becomes steel hard at cone 05.

The material when worked up in a plastic condition could be employed for common or face brick, especially if the latter were re-pressed. It might also serve for making the rough-surface face brick so much used at the present time. While I would hesitate to recommend this shale for sewer-pipe or paving brick, I believe that it could be mixed with a more plastic and more easily vitrifying clay for making these two kinds of ware. Another use which suggests itself is the employment of this shale for the making of red quarry tile. These form a very desirable product for paving courts and porches. They are about 8 inches by 8 inches by ¾ inch.

Samples of the red shale were also tested in the dry press form after grinding and passing through a 20-mesh sieve. No trouble was experienced in moulding the shale, but unless it is finely ground the brick have a granular appearance. The colour of the dry-pressed bricklets was a bright red, but it was necessary to burn them to cone 1 to obtain a hard product. At cone 010 the material had no ring; at cone 05 it was still too soft. At cone 1 the fire shrinkage was 2·5 per cent and the absorption 12·70 per cent. Both these figures are perfectly allowable.

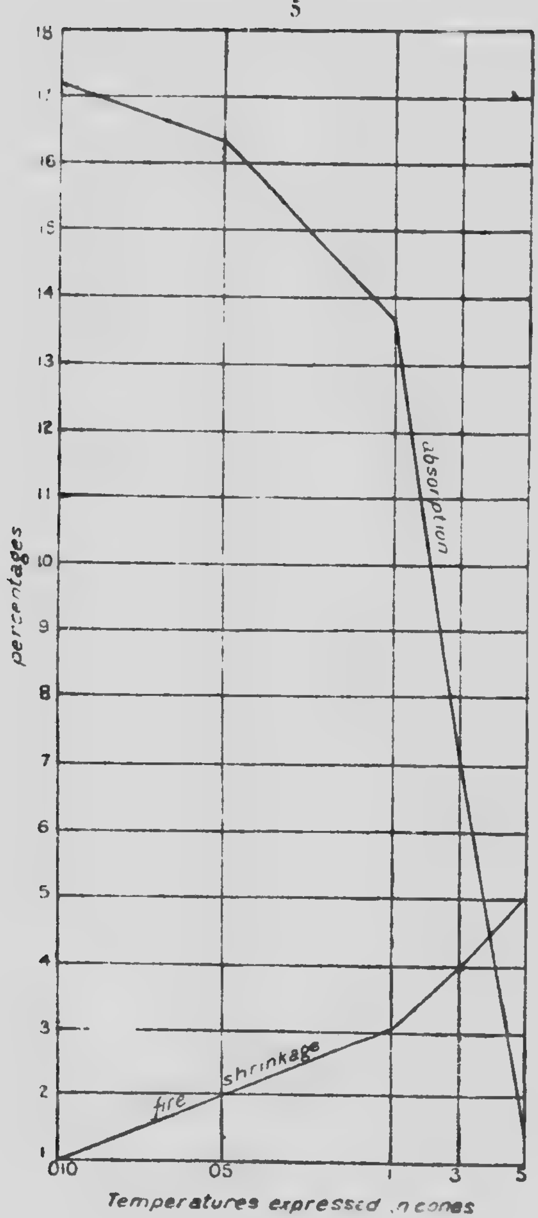


Figure 1. Fire shrinkage and absorption curves of shale, Laboratory Sample No. 1942, from Blue mountain.

The tests on a mixture of the red shale and the blue shale are described after discussion of the latter.

Blue Shale (Lab. No. 1943).

This is Turner's blue shale, and represents the best of the series tested, for it can be classed as a fireclay.

Like the other shales from this locality it is fine grained and dense, but when ground dry through a crusher set to one-sixteenth inch, it did not develop a very plastic mass, in fact the plasticity was not sufficient for satisfactory moulding.

A second lot of the material was, therefore, ground up wet, as would be done if a wet pan were used, and this resulted in considerable improvement, for the clay so ground developed excellent plasticity. Its air shrinkage of 8 per cent was a little high, but in practice it would probably be lower.

These wet-moulded bricklets were then burned from cone 010 to cone 15 with the following results:

Laboratory Sample No. 1943.

Cone	Fire shrinkage %	Absorption %
010	2·8	17·60
05	4·4	15·55
1	5·6	10·35
7	7·0	7·00
9	7·4	5·1
15	11·5	2·6
30	Fused	

These tests are also represented graphically in Figure 2. The bricklets burned to a buff coloured body which was steel hard at cone 05, but at cone 010 the body was too soft although not excessively porous. As the tests will show the shale burned to a fairly dense body even at cone 1, without excessive fire shrinkage. The fact that it fused at cone 30 shows that the material represents a fair grade of fireclay.

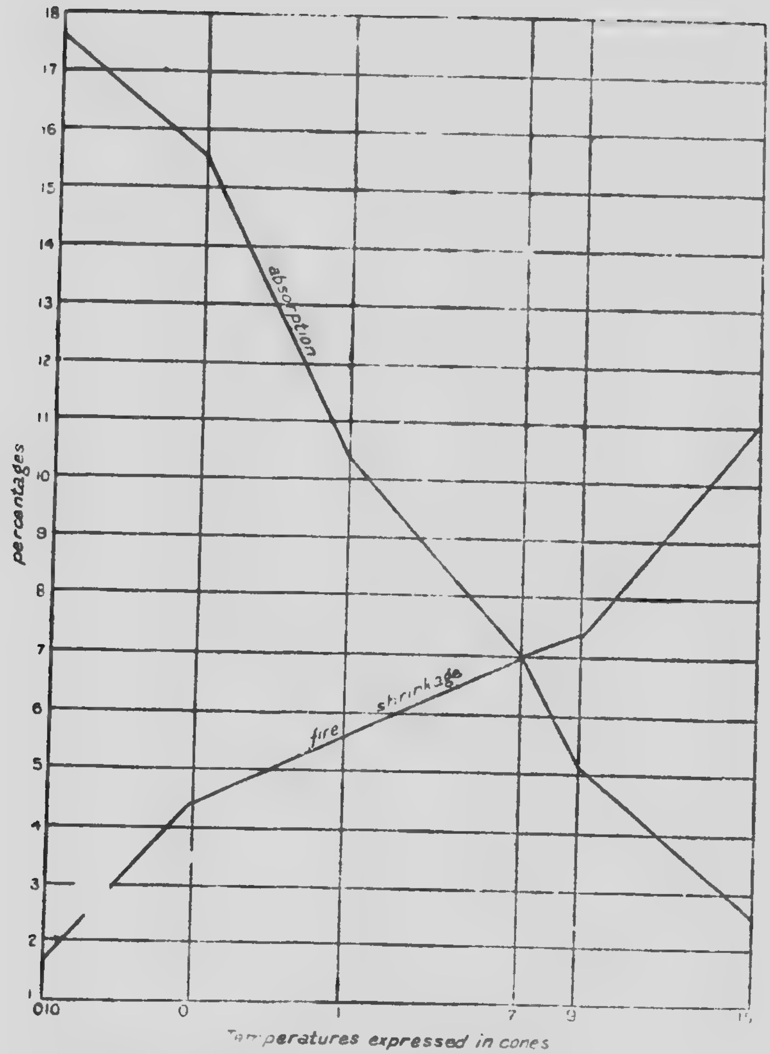


Figure 2. Shrinkage and absorption curves, shale, Laboratory Sample No. 1943, Blue mountain.

In its plastic condition it could be utilized for making pressed brick, and also firebrick, but if used for the latter purpose some grog would have to be added to the mixture. It is also nearly as refractory as the fireclays found in Sumas mountain. I think this shale could be employed as an ingredient of terra-cotta. Some of the dry-ground shale was moulded dry-press, and gave a very attractive, smooth, mottled buff brick, which in my opinion is as handsome and pleasing as any that I have made from Canadian clays. To give a hard dry-pressed product it requires burning to cone 1. At cone 1 the fire shrinkage was 6·4 per cent and the absorption 9·10 per cent. At cone 5 the fire shrinkage was 6·4 per cent and the absorption 6·4 per cent.

Grey Shale (*Lab. No. 1944*).

This is from the tunnel up the tributary stream, already mentioned, and while grey when fresh, turns reddish on exposure to the weather.

It is less dense and less coherent than the two already described, for after dry grinding in the crusher, it gives a mass of good plasticity when mixed with 29 per cent of water. The average air shrinkage was 8·5 per cent, and the tensile strength was about 25 pounds per square inch. The shale did not flow very well through an annular die, although I believe it would behave much better if ground wet, as in a wet pan.

The wet-moulded bricklets made from the clay were nearly steel hard at cone 010, and completely so at cone 05. They burned to a reddish buff colour. The fire shrinkage was not excessive at the lower cones, and the absorption was moderate.

The burning tests on the bricklets are as given below:

Laboratory Sample No. 1944

Cone	Fire shrinkage %	Absorption %
010	3	13·72
05	3·3	11·25
1	5·4	9·28
3	6·5	6·63
5	7	5·5
9	8	3·8
15	8·6	1·2

This clay is not a fireclay, as it fuses below cone 27.

We have here a shale that would when wet-moulded burn to a dense brick. There is also a possibility that it might work for sewer-pipe, although the colour of the body might not be altogether satisfactory, as engineers prefer a red body. If no trouble is experienced in forcing it through a die, I believe the material could also be employed for fireproofing.

Some bars 12 feet by 1 foot by ⅜ inch were made up, in order to see how ribbons of it would behave, with reference to its use for roofing tile. These were supported on knife edge supports placed 10 inches apart, and fired slowly up to cone 1. The strips held their shape and showed no signs of sagging.[1]

The burning tests of the wet-moulded bricklets are graphically represented in Figure 3.

No difficulty was experienced in making dry-press bricklets of the shale. These showed an absorption of 17·21 per cent at cone 010; 12·50 per cent at cone 05, and 6·12 per cent at cone 1. The bricklets were steel hard at cone 05.

Mixture of Blue and Grey Shales (Lab. Nos 1943 and 1944).

As dry grinding did not give a mass of sufficient plasticity when the blue shale (Lab. No. 1943) alone was used, and as the grey shale (Lab. No. 1944) was of good plasticity, it was deemed desirable to try a mixture consisting of 50 per cent of each. This gave a mass that could be moulded without any difficulty, and burned to a buff colour. The air shrinkage was 6·6 per cent which is lower than that of 1944 or 1943 (after wet grinding). The bricklets were steel hard at cone 05.

The burning tests on these wet-moulded bricklets, which are also expressed graphically in Figure 4, follow:

---

[1]For earlier tests of this nature see Can. Geol. Surv., Memoir 25, p. 94, 1913.

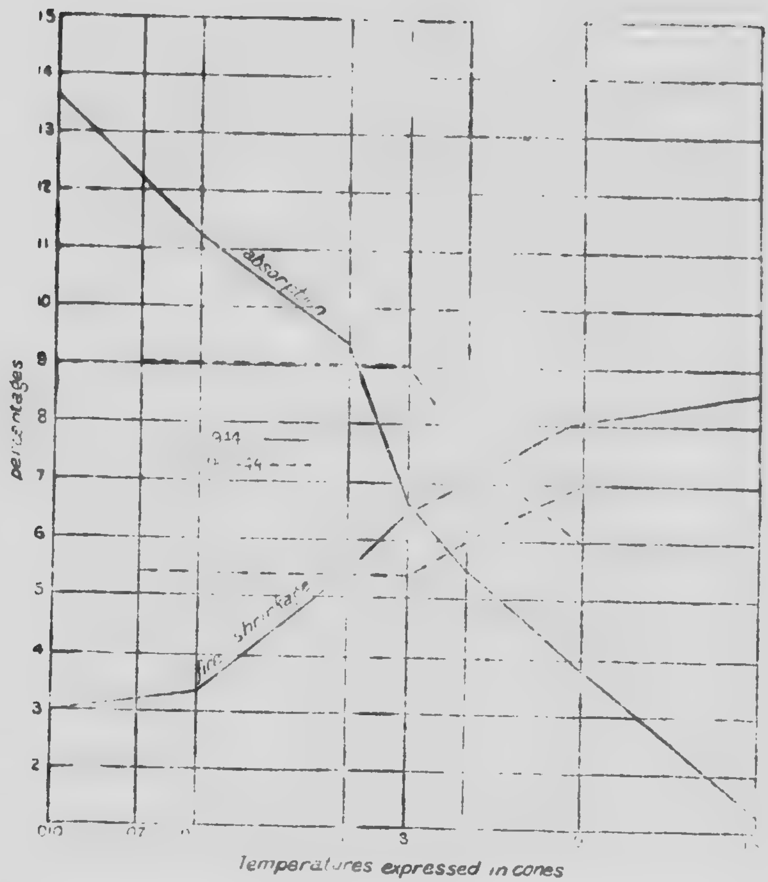


Figure 3. Shrinkage and absorption curves of Laboratory Sample No. 1944, and mixture of Laboratory Samples Nos. 1942 and 1944, Blue mountain.

Combined Laboratory Samples Nos. 1943 and 1944.

Cone	Fire shrinkage %	Absorption %
010	3·0	12·56
05	4·4	11·25
1	5·0	11·43
3	6·0	10·50
7	6·0	9·25
9	6·4	9·00
15	7·3	4·00

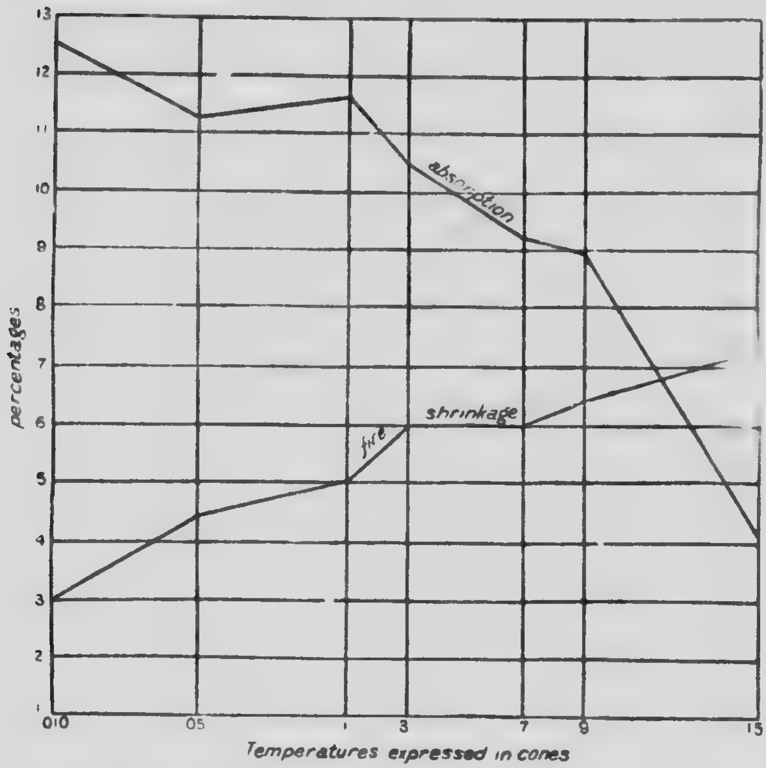


Figure 4. Shrinkage and absorption curves, mixture of Laboratory Samples Nos. 1943 and 1944, Blue mountain.

If we compare the shrinkage and absorption curves in Figures 2 and 3, with those in Figure 4, it brings out some interesting features, for we see that the fire shrinkage and absorption instead of being a mean of those expressed by the other two clays, average higher in the case of the absorption and lower i the case of the shrinkage.

Mixture of Red and Grey Shale (Lab. Nos. 1942 and 1944).

As the red shale (Lab. No. 1942) when dry ground was not highly plastic, and the grey shale (Lab. No. 1944) was strongly so, a mixture of equal parts of the two was made up. This gave a nice, smooth, plastic body which moulded easily and had an average air shrinkage of 5·6 per cent. The bricklets burned steel hard at cone 07, and were reddish in colour, but not the bright red of 1942 above. The burning tests yielded the following figures:

Combined Laboratory Samples Nos. 1942 and 1944.

Cone	Fire shrinkage %	Absorption %
07	5·4	9·0
1	5·4	9·0
3	5·4	9·0
5	6·0	7·6
9	7·6	6·0

In Figure 3 the tests on 1944 and the mixture of 1942 and 1944 are shown graphically. Figure 1 gives the tests on 1942. Comparison of these three sets of shrinkage and absorption curves, brings out the fact that up to cone 1, the fire shrinkage is higher and the absorption lower than in either of the shales alone, but that above cone 1, the curves of the mixture lie between the curves of the single shales, but approach more closely to those of 1944.

I think this mixture could be used for face brick or fire-

proofing, but it hardly burns dense enough for sewer-pipe, and is not vitrified even at cone 9.

White Clay (Lab. No. 1945).

There is some doubt regarding the exact amount of this clay present in the deposit, for its occurrence seems to be rather irregular. It is to be hoped, however, that a quantity of it may be found, for it is a material of excellent plasticity, which worked up with only 18 per cent of water. The air shrinkage was 5 per cent, being the lowest of any clays tested from this mountain.

The shale burns to a cream or bright buff colour and is nearly steel hard at cone 010. The fire shrinkage is not high at the lower cones. It will also be seen from the tests that the shrinkage increases between cones 1 and 5, and that the shale is practically vitrified at cone 15 (see Figure 5). It does not appear to be as refractory as the blue shale (Lab. No. 1943). The burning tests were as follows:

Laboratory Sample No. 1945.

Cone	Fire shrinkage %	Absorption %
010	3·3	14·25
05	4·0	14·18
1	6	10·40
5	9·4	4·65
7	9·0	4·6
15	9·6	2·2

If enough of this clay is found, I believe it could be used for making face brick, or in a mixture for architectural terracotta. The material also lends itself to dry-pressing.

Summary.

We have in this series of materials from Blue mountain an interesting set of shales. In thickness of deposit they remind

one of the shales found in Sumas mountain, south of Mission Junction, but present certain marked differences. They are softer than the shales worked at Kilgard and Abbotsford, and

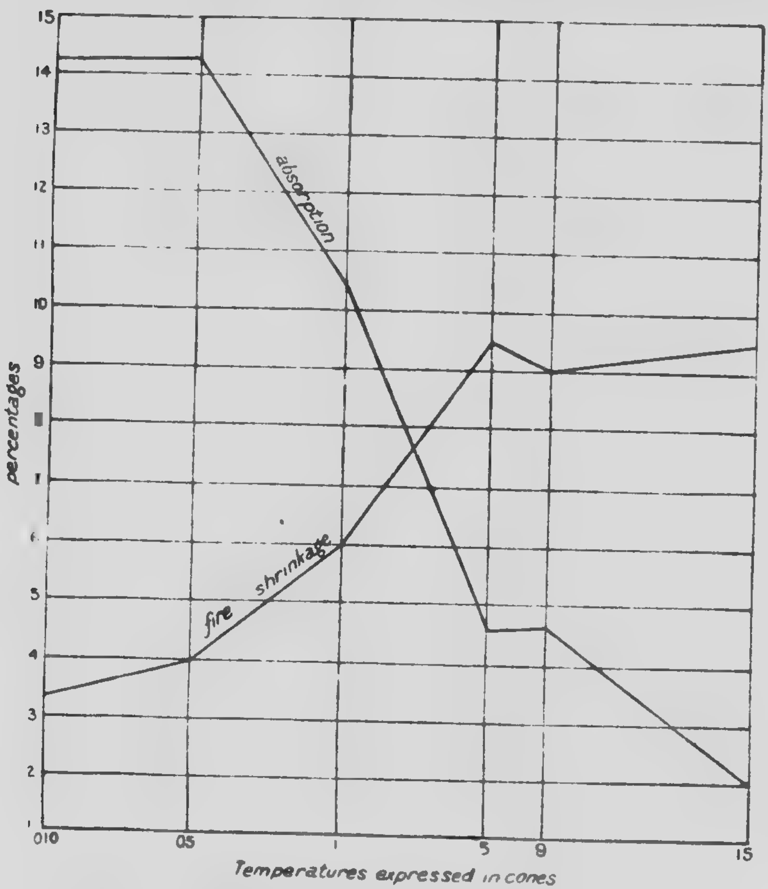


Figure 5. Shrinkage and absorption curves, shale, Laboratory Sample No. 1945, Blue mountain.

hence grind up easier, but differ from many of these in showing a slightly higher shrinkage, at the lower cones especially. What their extent is, cannot be definitely told until borings have been made and trenches dug.

We can say that these clays if properly handled should make the basis of a face-brick industry; that one at least, the blue shale (Lab. No. 1943), is a fireclay; and that there seem possibilities for u ; these materials in terra-cotta, fireproofing, and sewer-pipe manufacture.

KILGARD, B.C.

In the report covering the field season of 1910,[1] some attention was paid to the shale deposits of Sumas mountain. The deposits, as previously mentioned, are a portion of the Fraser delta constructed in Eocene time. Since they represent delta formations, it is not unnatural to expect them to show some variation, and as a result we find beds of sandy and clayey material alternating, all of them now more or less consolidated; and yet, the variations are not rapid, so that each kind of material may form a bed or lens of considerable size.

When Sumas mountain was visited in 1910, one plant was in operation at Clayburn, viz., that of the Clayburn Fire Clay Co. Ltd., while a second one was in contemplation, at Kilgard on the south side of the mountain. The first of these plants has been in active operation since, and additions have been made to it, including a unit for manufacturing fireproofing. The plant at Kilgard has been completed, but at the time of my visit was idle. It was most completely equipped for manufacturing dry-pressed brick, sewer-pipe, and firebrick (Plate I).

In the two years separating my visits to this locality, considerable clearing had been done on the southern exposure of the mountain, above the works, so that a much better chance was afforded for viewing the section. For this reason we give below a more complete statement than could be supplied in our earlier report.

At the bottom of the slope, an opening had been made in slightly kaolinized volcanic rock. Most of it is fine grained, rather free from iron, and occasionally shows scattered grains of pyrite. The purer parts of this have been called china-clay, although it is not really such. It is, however, of refractory nature. This rock is called No. 1.

[1] Ries and Keele, Can. Geol. Surv., Memoir 24-E, p. 125, 1912

Above this rock No. 1 is a bed of fireclay known as No. 2, which lies beneath a thin bed of coal, while the latter is covered by shale. Between the No. 2 bed of fireclay and the wagon road are several beds of shale. Just below the level of the wagon road, there are two beds of fireclay known as No. 3 and No. 4, which are separated by a parting of coal 6 inches thick. The No. 3 clay is 5 to 6 feet thick, and the No. 4 consists of a lower portion 14 to 18 inches thick, and an upper portion about 6 feet thick. A tunnel about 175 feet long had been run in, taking out both 3 and 4.

About 50 feet higher up is No. 5 which averages 6 to 8 feet in thickness. This has been penetrated by a 275-foot tunnel with about 400 feet of side entries. Some 20 feet above No. 5 is No. 6 with a thickness of 7 to 9 feet and a good sandstone roof. This shale has been penetrated by a tunnel 85 feet long.

No. 7, coming next above, is 6 feet thick.

No. 8, still higher up, is 6 to 8 feet.

No. 9 is about 7 feet thick.

No. 10 averages 13 to 14 feet in thickness.

No. 11 is a smooth shale 8 to 10 feet in thickness.

No. 12, which is the highest of the shale beds, is probably not less than 40 or 50 feet in thickness. It is reddish brown in colour and somewhat sandy. The several beds from 3 up are separated by beds of sandstone and sandy shale.

Character of the Shales.

This may be briefly summarized as follows:

No. 2. This makes an excellent No. 1 firebrick whose analysis was:—

Silica	62·80 per cent.
Alumina	35·00 " "
Ferric oxide	1·80 " "
Lime	0·20 " "
Magnesia	trace
	99·80

No. 3. This burns to a somewhat dense body, and brownish colour at cone 4. It is semi-plastic, and can be mixed with No. 5 to make a face brick. If used alone it may work for sewer-pipe.

No. 4. The lower bench burns to a pleasing brown colour, and gives a slightly denser brick than the upper bench. The upper bench makes a firebrick. No. 4 alone is used for the best grade of firebrick although it is said to be not quite as good as No. 2. The upper No. 4 is thought to be suitable also for making coke oven brick.

No. 5. This is used for dry-pressed face brick which burns to a buff colour at cone 10. These also take a good flash.

No. 6. The shale from this bed has been employed for dry-press brick. It has also given favourable results when used for sewer-pipe.

No. 7. This shale is buff burning, but had not been used.

No. 8. The bed is divisible into three benches which beginning at the top, burn respectively to a buff, grey buff, and grey colour.

No. 9. This is a plastic, buff-burning material.

No. 10. This is a sandy, red-burning shale, which vitrified about cone 2. It is claimed to be suitable for drain tile and paving brick.

No. 11. A red-burning shale, regarding which little else was definitely known.

No. 12. This is known to be red-burning, but has not been used.

NANAIMO AND VICINITY.

The east coast of Vancouver island, especially south of Nanaimo, continues to be a scene of somewhat unwarranted activity in the clayworking industry. I feel justified in saying activity, for this does not necessarily imply the accomplishment of positive results. The basis of this activity is the shale of the Nanaimo series. The somewhat unsatisfactory character of this material has been commented on in two previous reports,[1]

[1]Memoir No. 25, p. 78, et. seq., and Memoir 47, p. 64.

but development still goes on. The chief objection to this shale is its hardness and grittiness, so that even when finely ground it does not develop much plasticity. Occasionally when well weathered the material for the first few feet below the surface is a little more tractable, but most of the outcrops seem to have been very little altered by the weathering agents.

In order to bring out this point let us refer to the shale being worked by the Dominion Brick and Tile company on the west side of Gabriola island, opposite Mudge island. The beds exposed here (Plate II A and B) are a little less gritty than many of the others of this series, although they contain scattered sandstone layers. When this plant was visited in the summer of 1912, only a small opening had been made and this was in the buff-coloured somewhat weathered material. By the summer of 1913, however, the excavation had penetrated the blue shale which was harder, less plastic, showed lower fire shrinkage and higher absorption.

To bring out the comparison more clearly, the tests of the two are placed in parallel columns, while the absorption and fire shrinkage are shown graphically in Figure 6.

Laboratory Samples Nos. 1928 and 1927.

Buff or weathered shale (Lab. No. 1928)		Blue or unweathered shale (Lab. No. 1927)
Water required	2·2%	18%
Air shrinkage	7·6%	5%
Plasticity	Good	Only fair
Colour burned	Red	Red
Cone 010		
Fire shrinkage	1·4	0·6
Absorption	13·43	12·54
Cone 05		
Fire shrinkage	4·4	4·0
Absorption	9·18	12·07
Cone 1		
Fire shrinkage	7·4	6·00
Absorption	0·78	2·49

	Buff or weathered shale (Lab. No. 1928)	Blue or unweathered shale (Lab. No. 1927)
Cone 3		
Fire shrinkage	Nearly fused	5·00
Absorption...	...	3·00
Cone 010		
Fire shrinkage	0	
Absorption	14·33	11·88
Cone 05		
Fire shrinkage	5·00	4·7
Absorption	11·07	10·63
Cone 1		
Fire shrinkage	7·5	
Absorption...	1·0	

In the dry-press the unweathered seemed to burn denser than the weathered. [illegible] The buff shale burns to a deeper red. While this particular shale burns to a good red product, still there is not a little loss from cracking. There is a possibility that this shale could be put through a stiff-mud die, but it is not suggested.

Not far from here, in 1913, two properties were being developed. One of these was on the shore of Vancouver island just west of Mudge island. The shale here (Lab. No. 1933) was very gritty, and even when finely ground had very little plasticity; in fact some would call it non-plastic. Indeed it was impossible to mould it in the wet condition. We did succeed in making some dry-press bricklets and these burned to a red colour. Their absorption was 24·90 per cent at cone 010; 11·11 per cent at cone 05; and 2·24 per cent at cone 1. I cannot regard this as an attractive proposition.

Only a few hundred yards away on the south shore of Mudge island (Plate IIIA), another shale deposit was to be developed, and preparations were under way to establish a brick-yard The shale here was as gritty and untractable as that just described, and the geologic conditions were much worse. The shale forms a steep bank along the water's edge, and is overlain by massively

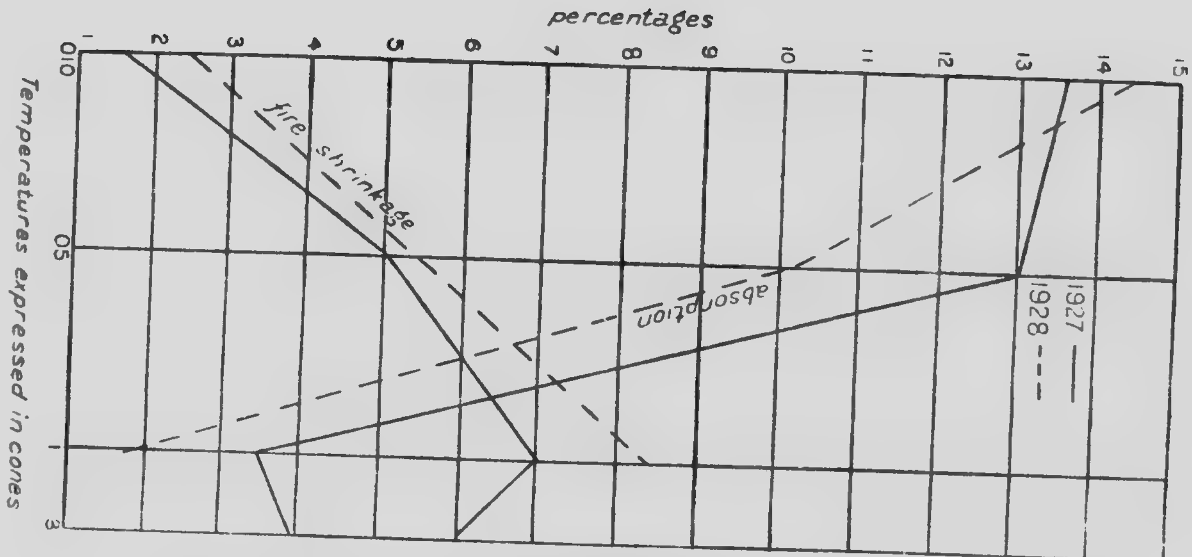


Figure 6. Shrinkage and absorption curves of unweathered (1927) and weathered (1928) shale, Gabriola island, near Nanaimo, B.C.

bedded sandstone. The bank cannot be quarried in very far from the face without undermining the sandstone. Moreover the sandstone extends down to the water's edge a short distance to both the east and west (Plate IIIB) of the shale bank. The successful development of this deposit both on account of its location and character seems very doubtful.

PRINCETON, B.C.

The rocks around Princeton consist chiefly of sediments of Oligocene age: sandstones, shales, and conglomerate with coal seams. These shales are of variable character, ranging from sandy to fine-grained ones, and from those which are very carbonaceous to others which seem to carry little carbon. These different types may alternate with each other and with coal seams. There are no extensive outcrops of shales at Princeton, the best observed being in the cut near the cement works 2 miles east of Princeton, and on the east side of the Similkameen river, at the end of the wagon bridge.

In last year's report on the western clays and shales[1] reference was made to a very plastic clay from the coal mines at Coalmont, which proved to be of refractory character. As only a small sample of it was obtainable, another visit was paid to the locality this year in order to study it further, but the mine had been closed down.

An effort was then made to obtain samples of any available clay or shale beds around Princeton, other than those already examined. The first of these was found in the Empire mine, 2 miles east of the town. Here, the coal which dips about 45 degrees south, is overlain by a coarse arkose, but between the latter and the coal is a very persistent but not always sharply defined, bed of clay which varies in thickness from 6 inches to 2 feet, but is usually nearer the latter figure. It is of dark brownish grey colour and contains scattered particles of carbonaceous matter. There would be no profit in working the clay alone, but it could be mined in connexion with the coal.

---

[1]Memoir 47, Part III.

A sample of the material (Lab. No. 1931) was tested in some detail. It was so smooth and plastic that no trouble was experienced in running it through an annular die, but the tiles cracked on air drying. A mass of the clay was then mixed with water for other tests. This took 29 per cent of water, and its air shrinkage of 9·3 per cent was somewhat high. The average tensile strength when air-dried was 96 pounds per square inch. The clay burns buff at the lower cones, but changes to brown at the higher ones. It is steel hard at about cone 05.

The other tests were as below:

Laboratory Sample No. 1931.

Cone	Fire shrinkage %	Absorption %
010	1·7	16·76
05	4·1	13·25
1	6·3	9·04
3	7·4	7·85
5	7·4	3·2
9	—	0·9
15	Nearly fused	

Even at cone 9, the clay showed fused spots. The material is not a fireclay, but it burns to a good colour for pressed brick, and could be dry pressed.

There is not enough clay in sight to warrant the establishment of a brick plant, but if one were started for common brick manufacture in the vicinity, and there was an occasional call for dry-press brick, this material could be drawn upon to feed a small press.

A sample (Lab. No. 1919) represents a shale outcropping in the railway cut between the Empire mine and the Cement mill. The shale appears to be moderately soft and the beds dip to the southward. The upper part of this shale mixed with the surface soil is said to have been utilized for making common brick, but they were rather porous. Many highly plastic clays containing large quantities of colloidal matter have a greasy

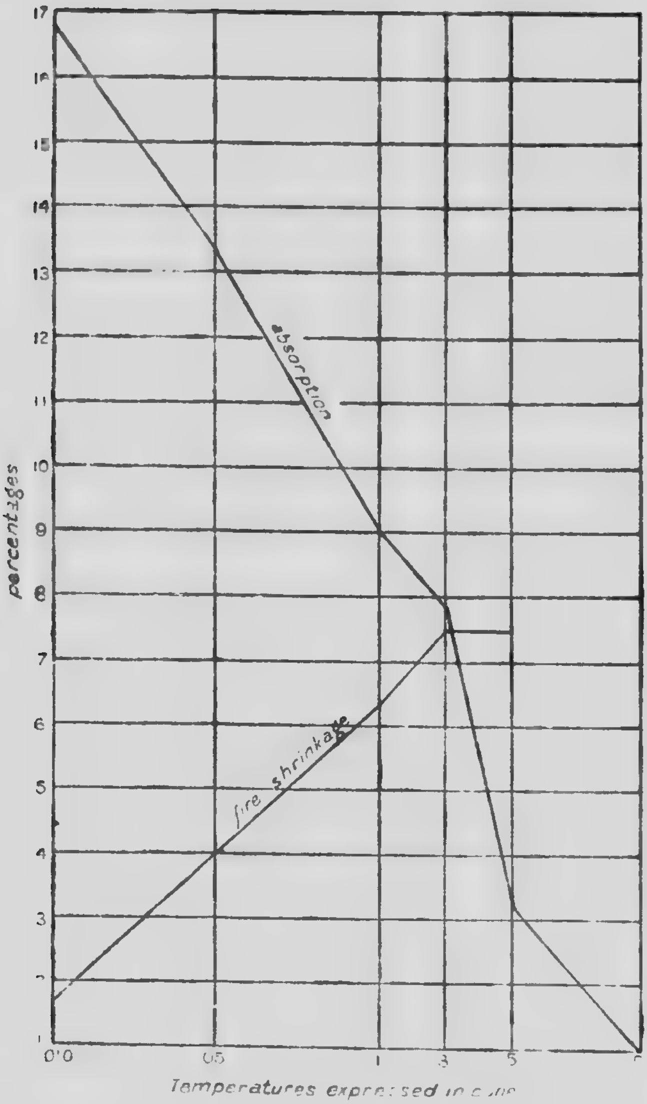


Figure 7. Shrinkage and absorption curves of preheated shale from Empire mine, Princeton, B.C.

look, but this shale shows none. However, when ground and mixed with water to a plastic mass, it cracked badly in drying, showing the high air shrinkage of 13·6 per cent. The latter alone would make the clay unfit for use by any plastic method, unless some material of low plasticity could be added to it. It is possible that it could be mixed with some of the hard gritty shale that outcrops farther down the track below the cement works.

The shale alone can, however, be moulded dry press, according to our experiments, but the bricklets did not yield a good ringing product much below cone 1. Their colour after burning was red, and the body was somewhat granular, but not sufficiently so to be objectionable. At cone 010, the dry-press bricklets were not steel hard, or even hard enough for use.

At cone 05, the bricklets had an absorption of 22·25 per cent, and at cone 1 of 6·60 per cent.

Tests on Preheated Clay (Lab. No. 1919).

A sample of the clay was preheated to 300 degrees C., which reduced its stickiness when wet as well as its excessive air shrinkage, so that it could be moulded without much difficulty. The air shrinkage of the preheated clay was 7 per cent, which as can be seen, was considerably less than that of the untreated material.

These bricklets were burned at 3 cones as follows:

Laboratory Sample No. 1919.

Cone	Fire shrinkage %	Absorption %	Colour
010	1	17·10	Dark pink
05	3·3	10·20	" "
1	7	6·10	" brown

The clay was steel hard at cone 1, and nearly so at cone 010. It showed some scum due to the presence of soluble salts in the clay. For graphic representation of the tests see Figure 8.

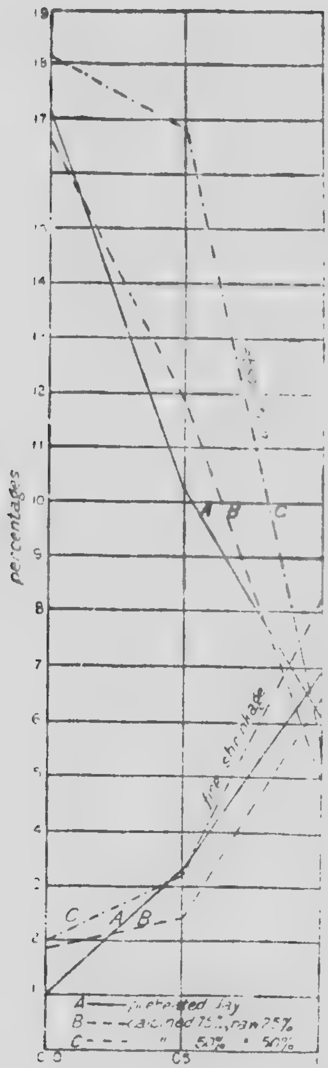


Figure 8. Shrinkage and absorption curves of raw and calcined clay mixtures, Princeton, B.C.

Tests on Mixtures of Calcined and Raw Clay.

In a second series of tests sample No. 1919 was heated to dull redness, which had the effect of destroying the plasticity. A mixture (Lab. No. 1950) was then made up consisting of 75 per cent of the calcined clay, and 25 per cent of the raw material. This mixture when worked up with water gave a mass that could be moulded without any trouble. Its average air shrinkage of 8 per cent was a little high. The clay burned to a salmon colour up to cone 010, and a dark red from cone 05 to cone 1. It was nearly steel hard at cone 010 and completely so at cone 05. The other figures of the burning tests were as follows:

Laboratory Sample No. 1950

Cone	Fire shrinkage %	Absorption %
010	1·85	16·58
05	2·4	11·76
1	6·6	4·92

The next mixture (Lab. No. 1951) consisted of 50 per cent of the calcined clay and 50 per cent of the raw material. This when worked up with water was fairly sticky and very plastic, but no trouble was experienced in moulding it. The average air shrinkage was 6·5 per cent and the average tensile strength 81 pounds per square inch. The clay burns red and is nearly steel hard at cone 010.

Laboratory Sample No. 1951

Cone	Fire shrinkage %	Absorption %
010	2	18·16
05	3·3	16·80
1	8·3	5·52

Comparison of 1950 and 1951 shows the latter to have a higher fire shrinkage and higher absorption, which is not what we might expect.

The shrinkage and absorption curves of the three clays are shown in Figure 8.

The material is not a fireclay. It could be made into red brick, but if used alone would have to be preheated before it could be moulded by any plastic process.

PRINCETON COAL AND COKE COMPANY.

The mine of this company is located on the east side of the Similkameen river, east of Princeton. The coal and associated shales dip southwest, and an exposure of coal and shales is seen along the river bank to the northwest. The coal company is working a bed of coal that is from 20 to 24 feet thick. There is a roof of black shale over the coal which is of no value.

About 14 feet above the coal and underlying an upper coal bed, is a greyish, greasy-looking clay (Lab. No. 1934) that weathers to a white colour. The bed of it runs about 2 feet in thickness. The very light colour of the dried material suggested that it might be rather free from iron, and hence it was desirable to determine whether it was a fireclay. While it turned out to be non-refractory, it was nevertheless extremely interesting. The material is exceedingly sticky and plastic, as well as being remarkably fine grained, and it is quite evident that its high plasticity is due to its content of colloidal matter.

The following partial chemical analysis was made:

Total silica	75·20 per cent
Hydrous silica	3·66 " "
Alumina	11·39 " "
Ferric oxide	1·83 " "
Carbonaceous matter	0·21 " "

The shrinkage and absorption curves are given in Figure 9.

In order to determine whether the hydrous silica and the carbonaceous matter were evenly distributed, or confined to the finer particles of the clay, a sample of it was stirred up in

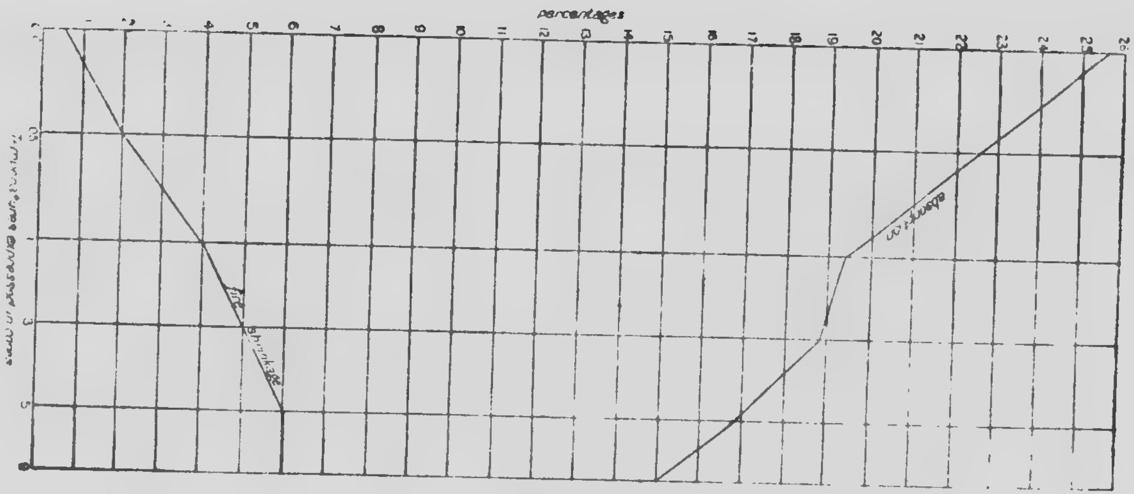


Figure 9. Shrinkage and absorption curves of preheated clay, Laboratory Sample No. 1934, Princeton Coal and Coke company.

water, and that portion which remained suspended was examined with the result that it showed:—

Hydrous silica....................	9·25 per cent
Carbonaceous matter	0·20 " "

One might expect from the comparatively low iron content that the material was a refractory clay, but it is not, for it fuses at cone 15. The fusion may no doubt be helped by the hydrous silica which appears to exert a strong fluxing action.

Further comments on the plasticity of this clay will be left until the other Princeton materials have been discussed.

Turning now to the physical tests of this clay, it was found that the raw material required 49 per cent of water to work it up to a pasty mass. This was an excessive amount and the bricklets cracked and shrunk to such a degree in the air drying that nothing could be done with them. A sample of the clay was, therefore, heated to 300 degrees C. This had the effect of almost completely eliminating the air-cracking and reduced the air shrinkage to 5 per cent.

The bricklets moulded from this preheated clay were then burned at different heats up to cone 15 at which it fused, the surface of the test piece becoming glassy. The clay burns to a porous, buff-coloured body, and is rather light in weight. The surface shows a network of small cracks which developed in the burning and not in the drying.

The burning tests were as follows:

Laboratory Sample No. 1934.

Cone	Fire shrinkage %	Absorption %
010	0·6	25·15
05	2·0	25·50
1	4·0	19·36
5	5·0	18·80
9	6·0	16·80
12	6·0	15·00
15	Fused	

The under clay (Lab. No. 1932) forms a bed about 2 feet thick below the main coal bed. The material is very sticky, highly plastic, and apparently carbonaceous in its character. On account of its excessive plasticity the clay cracked badly even when dried slowly at room temperature, and had an air shrinkage of 11 per cent. A sample of the clay was then preheated to 300 degrees C., ground and moulded. It was less plastic after preheating, and the air shrinkage was reduced to about 8·5 per cent, but the clay still cracked badly. As it was not considered practicable to heat it above 300 degrees C., no further tests were carried out on the material.

NORTH OF PRINCETON.

The Tertiary shales and sandstones outcrop along the Great Northern railway at the southwest end of the tunnel, but the beds are usually sandy, and the shale in small lenses.

The Plasticity of the Princeton Clays.

All of the clays described from the Princeton district are excessively plastic and sticky, and it may [illegible]t be out of place to say a few words regarding their pla[illegible]lities. A theory quite widely accepted now, but not fu[illegible]en, is that the plasticity of clay is due to colloidal mat[illegible] of either organic or inorganic nature. The reason for saying that the theory is not fully proven is because there is strong reason to believe that other factors besides colloids, may, sometimes, at least, be operative.

In order to get some further light on this subject, three very plastic clays were selected from the Princeton district,[1] including samples 1919, 1934, and 1932, and a fourth sample, Lab. No. 1765) from Tofield, Alberta. Fifty-[illegible] samples of each of these were weighed out, and shaken up in 1000 cc of distilled water. The jars containing these were allowed to stand 24 hours.

[1]The laboratory tests on these were carried on by N. B. Davis.

Samples were then taken by means of a pipette from different depths, and the size of the larger particles measured in each case. One clay (sample 1919, see Plate IV A) which appeared to have considerable absorbed salts, settled in a few hours. The others showed considerable material remaining in suspension even at the end of 20 days. At the end of this period, pipette samples were again taken from different depths, and another set of measurements made. This time the particles in suspension in 1934 and 1932 were so small that they could not be seen with a magnification of 600 diameters. The particles in 1765 on the other hand were visible, and measured 0·002 millimetres in diameter.

The sizes of the particles remaining in suspension in clays 1934, 1932, and 1765 at the end of 24 hours are shown by the curves in Figure 10.

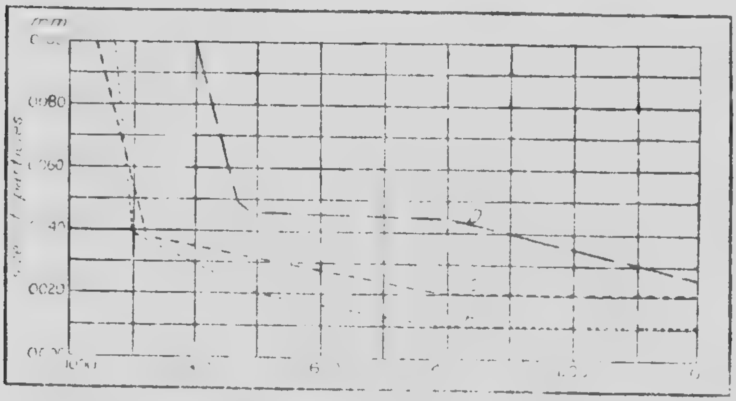


Figure 10. Curves showing size of particles in suspension at end of 24 hours in clays of high colloid content.

A study of the curves indicates that something is probably present in the case of 1765, which causes larger particles to remain in suspension than in the case of clays 1934 and 1932. This difference in the suspended material suggested a possible difference in the nature of the colloidal material present, so determinations of colloidal matter were made in samples 1934, 1932, and 1765.

In extracting the hydrous silica, the relative depth of colour of the solution in 1934, 1932, and 1765 suggested that the per cent of colloidal organic matter increased towards 1765. These determinations are given below:

	1934	1932	1765
Hydrous silica	3·66	0·76	0·12
Carbonaceous matter	0·21	0·65[1]	1·10

Comparing these three sets of determinations we see that the hydrous or colloidal silica decreases from 1934 to 1765, but that the carbonaceous matter of colloidal nature increases in the same direction. Now it is known that organic colloids are supposed to have a greater effect on plasticity than inorganic colloids, and both 1932 and 1765 are more plastic than 1934. The action of the organic colloid is probably two-fold. In the first place it may increase the viscosity of a mixture of water and suspended clay particles, and in the second place it may act as a protective colloid, and hold the clay particles in suspension. It is significant then, that in 1765 which contained more organic colloids, that after 20 days the clay particles remaining in suspension in 1765 were not only larger but more numerous than in the case of 1934 and 1932.

Now as to the conditions of formation of the clays in the Princeton basin, the fact that coal beds were laid down in the Tertiary formation carrying the clays, shows that there must have been considerable organic matter in the water in which the clay was laid down. No doubt much of this organic matter was in colloidal form, and was mixed with the clayey sediment. It may be asked why the organic matter in the clay is in a colloidal condition, while that of the coal is not. The latter became inspissated, while that in the clay may never have dried out to this condition; or if it did, prolonged exposure to moisture filtering along the clay beds may have changed it back to the colloidal form.

---

[1]The total quantity of carbonaceous matter (2·67%) was determined, but some of this was coaly material. It was estimated colourimetrically that 0·65 per cent was colloidal.

CRANBROOK, B.C., AND VICINITY.

The calcareous silts in the valley of St. Mary river at Cranbrook, have been referred to in last year's report, and their similarity to the silts of the Columbia valley commented on. These materials were very calcareous, cream burning, and yielded a highly porous brick.

In the year 1913 another yard was established about 2 miles west of Cranbrook by Mr. Hanson (Plate V A). The deposit worked here, lies not in the main valley but behind a ridge, and slightly above the terrace level in the valley proper. It seems to be a separate basin or small lake deposit, of very different character from the valley silts, as it is much more plastic and of better working quality. The clay is stratified, in layers one-half to 1 inch thick, separated by thin laminæ of sand, and there are only a few inches of soil overlying it. A thickness of 5 feet had been exposed (Plate V B). Like the valley silts it is calcareous, but not enough so to make a cream-coloured product.

It is sufficiently plastic to flow through a tile die. The clay (Lab. No. 1935) worked up with 20 per cent of water, and had an average air shrinkage of 5·4 per cent, and an average tensile strength of 87 pounds per square inch. Both wet moulded and dry-press bricklets were made with satisfactory results. The wet-moulded bricklets burned to a pink colour at low cones, and then red if well burned, but were not steel hard unless fired to cone 05, although thay had a good ring even at cone 010. The burning tests of the wet-moulded bricklets are as follows:

Laboratory Sample No. 1935.

Cone	Fire shrinkage %	Absorption %
010	0	26·43
05	1·0	20·80
1	10·7	0·10
3	Fused	

It will be seen from these tests that although the clay is not sufficiently calcareous to burn buff, it nevertheless shows some of the characteristics of a calcareous clay, in its rapid shrinkage and vitrification between cone 05 and cone 1. It should be burned at cone 05 if possible.

The burning tests of the dry-press bricklets were as follows:

Laboratory Sample No. 1935.

Cone	Fire shrinkage %	Absorption %
010	Too soft for use	
05	0·3	31·64
1	11·00	0·97

The dry-press bricklets at cone 05 were pink in colour, fine grained, and had a good ring, but the absorption was too high. At cone 1 the shrinkage was excessive and the colour dark brown. If dry-press brick were made of this clay they would probably have to be burned about cone 03 for the dual purpose of getting less absorption than at cone 05 and of avoiding the high shrinkage developed when burned at cone 1. The accompanying diagram Figure 11 shows in an interesting manner the relative sizes of the bricks at cone 05 and cone 1.

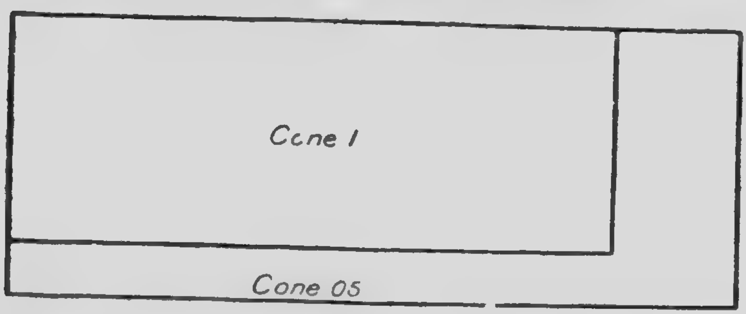


Figure 11. Sketch showing relative size of Hanson's clay bricklets moulded dry oven and burned at cone 05 and cone 1.

As to the uses of this clay, it could be and is manufactured into common brick. It would, I believe also, make drain tile. It lends itself to dry pressing. Lastly the smoother portions of the deposit could, I think, be moulded into earthenware such as flower pots. Mr. Hanson showed me some interesting and very creditable pieces of rustic pottery that had been modelled by hand from the material in his clay pit. At the time of my visit the product consisted wholly of common brick. The plant was equipped with pug mill, rolls, and side-cut stiff-mud machine. Drying was done on pallet racks, and burning in scove kilns.

Along the railway track at Wyckliffe station (Plate VI A) 6 miles northwest of Cranbrook, there is a strong outcrop of Pre-Cambrian metargillite. The material is a very hard schistose rock, which in some beds contains considerably more quartz than in others. A tunnel has been driven along one of the less quartzose beds, and at this point a sample for testing was taken. The material is not at all promising looking, and the only reason it was tested was because it was said to have been used for making brick, to line the smelter at Marysville, B.C. Even when finely ground, the material (Lab. No. 1941) had no plasticity so that it could not be wet-moulded. Some of it was then ground up very fine, moistened slightly with water and dry-pressed. These tests yielded the following results:

Cone 010. No ring to brick, body soft, colour red, absorption 12·58 per cent.

Cone 05. Little ring, absorption 12·28 per cent.

Cone 1. Fire shrinkage 1 per cent, bricklet barely steel hard, absorption 9 per cent.

The material is not recommended for brick manufacture, for it can barely be moulded even by the dry-press process, and even then has to be very finely ground.

In looking for good clays in this region, Mr. S. J. Schofield of the Geological Survey, pointed out to the writer a bed of dark grey clay located along the north bank of St. Mary river, about 4 miles above the St. Eugene mission. The bed outcrops at the base of a high bank, and has a thickness of about 5 feet. As the overburden is considerable it could not be worked

as an open pit, and could only be extracted by means of drifts. Neither is there evidence of a large quantity of the material. There would, however, be enough to supply a small pottery, the idea being that the material might be used for earthenware.

The clay was plastic, although it contained much very fine grit, and took 29 per cent of water for mixing. It had an average tensile strength when air dried of 57 pounds per square inch, and an air shrinkage of 4·2 per cent. It burns to a pink colour and does not become steel hard until cone 1. The fire shrinkage is not high up to cone 05, and while the absorption appears to be, it is often so in common earthenware made from some clays. The clay could probably be improved by washing, so as to remove fine grit.

The following are the fire tests on the bricklets:

Laboratory Sample No. 1946—Wet-moulded bricklets.

Cone	Fire shrinkage %	Absorption %
010	2	27·60
05	5	25·00
1	11	8·80
3	13	0·00

Laboratory Sample No. 1946—Dry-press bricklets.

Cone	Fire shrinkage %	Absorption %	Colour.
010	Soft, no ring when struck		
05	Fairly hard	26·88	pink
1	Not steel hard	16·82	

It would hardly be worth while to attempt making any dry-press forms of the clay.

CRESTON, B.C.

Goat river, a tributary of Kootenay river, joins the latter near Creston, and the Canadian Pacific railway follows the narrow valley of this stream from Goatfell to Creston. Along the line of the railway there are in this distance a number of clay cuts, which have given considerable trouble by sliding. These cuts, which are mostly of silty, laminated clay, are especially numerous between Kitchener and Erickson. Some of the cuts show stony or boulder clay, and in these there may be lenses of the laminated clays. All of these laminated clays are very silty and somewhat calcareous.

The deposits are not in all cases large enough to be worked, nor where they outcrop along the railway track, it might not in all cases be practicable to work them. They represent, however, a common type of clay in this region, and since they are best exposed along the railway, our samples were taken from these points.

A sample (Lab. No. 1930) was taken from along the railway about one mile northeast of Canyon station. It is a fine-grained silty material of fair plasticity, but at the same time exhibits the resistance to pressure, so characteristic of silty clays. It worked up with 23·8 per cent of water, had an average air shrinkage of 3·1 per cent, and an average tensile strength of 25 pounds per square inch. On account of its silty character the clay did not give results when moulded dry-press, but it did lend itself to the plastic method of working, and the test bricklets were formed in this manner. They burned to a pink colour, but did not become steel hard until cone 1, and in fact did not give a brick with real good ring unless burned to cone 05.

The other details of the burning tests are as follows:

Laboratory Sample No. 1930.

Cone	Fire shrinkage %	Absorption %
010	0	18·60
05	1	16·20
1	9·4	4·76
3	9·5	4·7
7	nearly viscous	

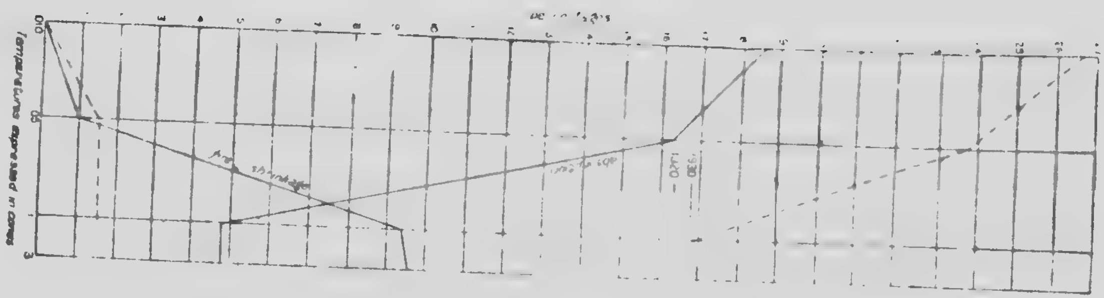


Figure 12. Shrinkage and absorption curves of clays from near Creston, B.C.

It will be seen from these tests that the clay does not become very dense until above cone 05, and that the great decrease in absorption at cone 1 is accompanied by a strong increase in shrinkage (Figure 12).

The clay is not plastic enough to flow through a die, and the only use suggested is for making common brick by the soft-mud process.

The best clay bank exposed along the railway track in the stretch mentioned is in the large cut at Goat canyon (Plate VI B). It is a typical silty clay, which bakes to a hard mass in dry weather, and runs easily in wet weather. The clay (Lab. No. 1924) is of greyish-yellow colour, somewhat calcareous, and of fair plasticity, but not enough to flow through a tile die. I required 30·8 per cent of water to work the clay up to a plastic mass, which had an average air shrinkage of 4·9 per cent. The average tensile strength when air dried was 45 pounds per square inch. The clay like many other silty ones swelled slightly at cone 010, and its fire shrinkage was practically zero up to cone 05. By cone 1 the shrinkage had increased to 10·3 per cent. The absorption was high in every case except cone 1, and ran as follows—cone 010, 25·80 per cent; cone 05, 24·00 per cent; cone 1, 0 per cent. This peculiar behaviour is due in part to its silty nature, and in part to its lime carbonate contents. The clay burns pink, but is not steel hard until fired above cone 05. It is at best only a common brick clay.

Along the road fron Creston to Goat canyon, and opposite the site of Lisk and Slater's old saw mill, there is a long outcrop of reddish brown clay, with very little stony material. The deposit, as nearly as could be determined without boring, is probably 15 or 20 feet thick. There is room here for a brick plant, and the locality is about 1000 feet by an air line from the railway. Similar clay outcrops at other points near by.

This material (Lab. No. 1920) is quite different in its nature from that in the railway cuts mentioned above, being less sandy to the feel and denser, but like the others is somewhat calcareous. It took considerable water to work it up, viz., 35 per cent, but yielded a mass that was sufficiently plastic to flow through a tile die. The average air shrinkage was 7 per cent, and the

average tensile strength when air-dried, 90 pounds per square inch. This was almost double that of the Goat Canyon clay. The clay burned to a red colour, and the bricklets had a good ring even at cone 010. The fire tests were as below:

Laboratory Sample No. 1920.

Cone	Fire shrinkage %	Absorption %	Colour
010	0	26·40	salmon
05	1·5	23·50	
1	1·7	16·87	red
3	Fused		

The curves are given in Figure 12.

The clay could be used for common brick as it is plastic enough to work. It burns hard at a low heat, and the only objection to it is the somewhat high absorption. However, the latter is not necessarily an indication of low durability. The clay could, moreover, be utilized in making drain tile, provided these did not have to be vitrified, but if they were burned to cone 1, the absorption would not be excessive. Even though the absorption of the brick made from this clay is somewhat high, the clay is better than several others which are used for brick in southern British Columbia. If the project of lowering the level of Kootenay lake is carried out, so as to unwater the delta lands south of Kootenay Landing, the drain tile which could be made from this clay should prove of value for draining these reclaimed lands.

Along the Erickson road, about 2½ miles from Creston, this same kind of clay again occurs, and here is not far from the railway track.

FORT GEORGE, B.C.

During the summer of 1913 the writer was shown two samples of greyish white clay which were said to have come from Giscome Portage, 30 miles above Fort George. One of

the clays is quite sandy while the other is smoother and contains only fine sand. The smoother and more plastic of the two clays is said to form a lower bed, and the more sandy material an upper bed, the whole being described as overlain by river gravel containing pebbles of quartzite.

Only small samples of each were available, so but few tests could be made on them, and these are given below. No. 1953 is known as the plastic clay, and 1954 as the sandy clay. The latter is decidedly gritty to the feel and even in appearance (when dry), but nevertheless its plasticity is good.

The burning tests are given below. It is quite possible that the more plastic clay may be of fair refractoriness, but the other on account of its sandiness would not stand as much heat. Both are nearly steel hard at cone 07. The air shrinkage of sample No. 1953 was 6 per cent. The burning tests were as follows:

Laboratory Sample No. 1953.

Cone	Fire shrinkage %	Absorption %	Colour
07	2·3	17·10	cream
1	3	15·40	buff
3	3	15·5	buff
5	5	10·20	
9	6·0	8·0	buff

The air shrinkage of sample No. 1954 was 4 per cent. The burning tests were as follows:

Laboratory Sample No. 1954.

Cone	Fire shrinkage %	Absorption %	Colour
07	1	14·0	cream
1	1	14·00	buff
3	1·5	13·5	buff
5	2·5	11·0	
9	2·5	9·5	buff

Nothing can be said regarding the extent of this deposit; but it is worth looking into. In its present location, there seems no immediate local use for the product, but if made into fire-brick or face brick, these could be shipped into Prince Rupert or Vancouver.

COLEMAN, ALBERTA.

In last year's report reference was made to the black Benton shale occurring west of Coleman, in the SW. ¼, sec. 7, tp. 8, range 4, W. 5th mer. This is a black shale, which dips into the hill, and is exposed for about 30 feet up the face of it, above which there is gravelly overburden about 30 feet thick (Plate VII).

The shale tested last year represented fresh material taken from a tunnel on the quarter section mentioned, and while it was found to be possible to make dry-press brick from it, the use of this material was not encouraged. This year some further tests have been made in order to do these shales full justice, and because the request was made that we mix this material with some other clays found in the vicinity.

Since weathering often improves a shale, tests were made on a sample of the black shale, which had been lying at the mouth of the assessment tunnel for about a year. This material (Lab. No. 1940) was as black and carbonaceous as the fresh rock, and had very little plasticity even when ground fine. Indeed, it is practically no better than the fresh shale, and could not be worked up in the plastic form.

The wet moulding having failed, it was then tried dry-press. The clay can be so moulded if it contains enough moisture. It burns to a red brick. The test bricklets were fired at different cones as follows:

Cone 010, bricklet granular, no ring, but held together. Absorption 12·32 per cent, which is not high.

Cone 05, ring poor, absorption 12·23 per cent.

Cone 1, good ring, bricklets steel hard, absorption 10·72.

It is possible to make a red dry-press brick from this shale, if care is used, but I cannot regard the attempt as hopeful.

The material is of excessive leanness, low coherence, and must be fired slowly and carefully on account of the carbonaceous matter which it contains.

A second sample tested was a shale from near this same locality (Lab. No. 1922) (No. 2 of Bradley). This had practically no plasticity and dry-press bricklets could be made of it only with difficulty. I do not see much advantage in using this material.

A third sample, Lab. No. 1926 (No. 3 of Bradley), was obtained from near the water-fall, upstream from the assessment tunnel. This was a clay of very different character from the shale. It is a slightly calcareous material of low plasticity, which required 22 per cent of water to mix it. The average air shrinkage was 4·3 per cent, and the average tensile strength not over 20 pounds per square inch. For this reason the air-dried bricklets are not very strong.

The clay burns to a reddish body, which is nearly steel hard at cone 010, and completely so at cone 05. The bricklets showed small fused spots and a tendency to crack slightly.

The burning tests on the wet-moulded bricklets were as follows:

Laboratory Sample No. 1926.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·8	18·20	pink
05	1·0	15·12	dark pink
1	1·4	14·73	dark pink

The absorption at cone 05 is not excessive and the fire shrinkage is low; but I question whether the clay could be used for anything but common brick. Better results would be obtained if the clay were dry pressed.

Finally a mixture (Lab. No. 1949) was made up consisting of equal parts of 1926 and 1940. This gave better results than any of the three materials used alone. It worked up to a mass

of fair plasticity with 14 per cent of water, which is not excessive. The average air shrinkage was low, being 4 per cent, and the average tensile strength when air dried was 25 pounds per square inch. This mixture could be either wet-moulded or dry-pressed, and each was tried.

The wet-moulded bricklets burned to a light red, but not as deep a colour as 1940 alone. The burning test was as below:

Laboratory Sample No. 1949.

Cone	Fire shrinkage %	Absorption %
010	0·5	15·00
05	1·0	14·10
1	1·0	11·12

A dry-press bricklet burned at cone 1 showed 9 per cent absorption.

This mixture could be used for common or pressed brick, but probably nothing else.

Since the Benton shales form a rather strong belt striking approximately north-south, it is possible that the shales in some other part of the belt might be of more desirable quality than those whose tests were given above.

PASSBURG, ALBERTA.

In a previous report on the shale deposits of the western provinces,[1] attention was called to a number of shale beds, interstratified with sandstones, which outcropped along the Canadian Pacific railway between Lundbreck and Burmis, most of which were red burning, but not in deposits of large size. These were classed at the time as Edmonton, although later determinations by members of the Survey seem to place them as Upper Cretaceous.

[1]Ries and Keele, Can. Geol. Surv., Mem. 24, p. 95.

In the season of 1913, more or less quiet prospecting has been done in the region east of the Crowsnest pass. This was occasioned partly by the reported discovery of high-grade clays on the South Fork and probably also by inquiries received from some of the clayworking establishments near Calgary.

Among the deposits that have been prospected is one located n Passburg, in sec. 11, tp. 7, range 3, W. 5th mer. The claim which is controlled by J. Kerr, of Passburg, and others, is about 200 feet from the Oldman river, about one-half mile south of the Canadian Pacific Railway track, and 2 miles west of Burmis station. The deposit is covered somewhat by the river terrace deposits, but the beds which are somewhat folded are of Blairmore (Dakota ?) age, according to Leach's map of 1912.

Six samples were supplied from different beds by Mr. Kerr as follows:

Lab. sample 1936, Kerr's No. 4, said to represent a 5-foot bed, the highest of the section.

Lab. sample 1939, Kerr's No. 3, from a 4-foot bed.

Lab. sample 1921, Kerr's No. 1, from a 4-foot bed.

Lab. sample 1920, from 8-foot bed abot' same level as 1921.

Lab. sample 1938, Kerr's No. 5, said to be 4 feet thick, and tc lie 20 feet below 1921.

Lab. sample 1937, Kerr's No. 6, said to lie 15 feet below No. 5, and to be 10 to 12 feet thick.

The deposit was more extensively opened up after the writer's visit to the region, and four of the samples were sent in later.

The following are the laboratory tests made on the samples, and conclusions drawn from them.

One sample (Lab. No. 1936) was a soft grey shale, that works up well to a plastic mass and could be made to flow through an annular die. The average air shrinkage was 8·7 per cent, which was a little high. It burns to a red colour, and is thoroughly vitrified at cone 1, in fact the bricklets deformed under the weight of a few courses of test bricklets resting on them. Fired at several cones the following results were obtained:

Laboratory Sample No. 1936.

Cone	Fire shrinkage %	Absorption %
010	1	10·00
05	3	7·43
1	5·4	0·09

The shale shows a low fire shrinkage, and the bricklets had a good ring even when burned only to cone 010. It will not stand burning above cone 1, or even that high, but at cone 03 should give a good dense brick. The absorption is not high even at the lowest cone at which it was tested. The material would probably make a vitrified product at a low cone. Figure 13 gives the graph of the burning tests.

A second sample (Lab. No. 1939) was a silty clay shale, which, however, has good plasticity, and worked up well to a plastic mass whose air shrinkage was 7 per cent. The shale burned pink at cone 010, red at cone 05, and brown at cone 1. It became steel hard at cone 05, but the bricklets had a good ring even at cone 010. The clay was vitrified and even somewhat softened at cone 1. It fused about cone 3.

Below are the burning tests:

Laboratory Sample No. 1939.

Cone	Fire shrinkage %	Absorption %
010	0	11·00
05	1·8	8·50
1	5·0	1·59
3	Fused	

From the tests on the wet-moulded bricklets the clay gives evidence of making a vitrified ware at a low cone. The graphs of the wet-moulded tests are shown in Figure 14.

Dry-press bricklets burned at cone 010 were too soft, but those fired at cone 05 had a good ring and 10·88 per cent absorption.

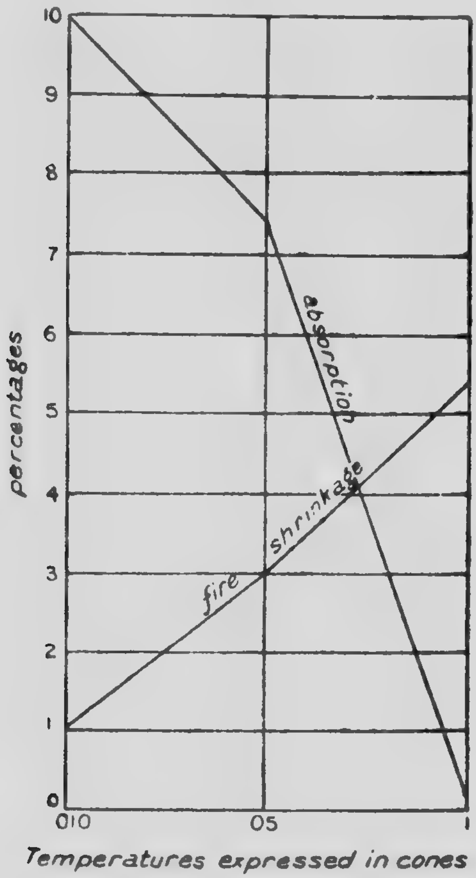


Figure 13. Shrinkage and absorption curves of shale, Laboratory Sample No. 1936, Passburg, Alberta.

A third sample (Lab. No. 1921) was a light grey shale, which when ground up and mixed with water gave a body of excellent plasticity whose average air shrinkage was 6·6 per

cent, and average tensile strength when air-dried was 30 pounds per square inch. No difficulty was experienced in forming

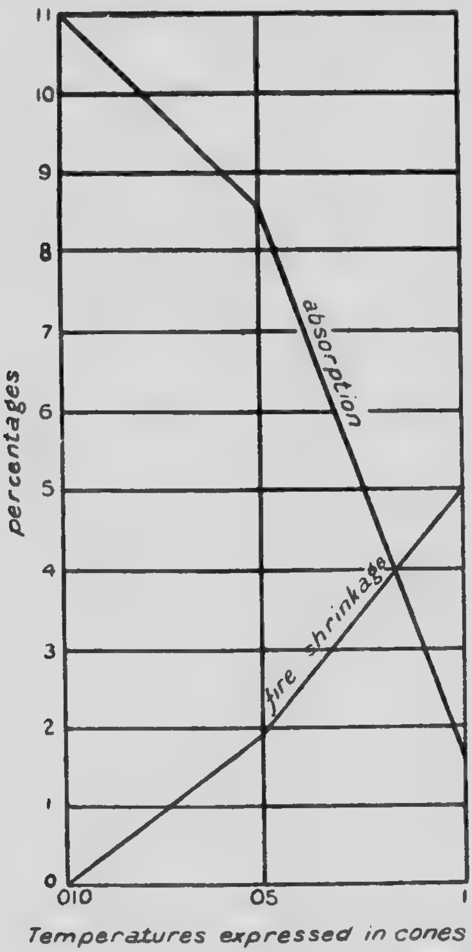


Figure 14 .Shrinkage and absorption curves of shale, Laboratory Sample No. 1939, Passburg, Alberta.

wet-moulded bricklets of the clay, nor in making it flow through an annular die. The bricklets had a good ring even at as low a cone as 010.

The burning tests were as follows:

Laboratory Sample No. 1921.

Cone	Fire shrinkage %	Absorption %	Colour
010	1·6	11·46	salmon
05	4·2	6·18	red
1	5·4	2·00	dark red
3	Fused		

The shale softened somewhat even at cone 1, and it would hardly be safe to burn it as high as this, if used alone. The fire shrinkage is not high, and neither is the absorption.

Figure 15 shows graphically the burning tests.

The clay could probably be moulded dry-press.

Several possible uses suggest themselves. The shale could be employed for making red brick, and possibly vitrified brick. It could also be moulded and burned at a low heat for drain tile. If the shale will take a salt glaze it should be tried for sewer-pipe. Fireproofing is another product that I believe could be made from this shale.

A fourth sample (Lab. No. 1920) is also a light grey shale of good plasticity, which worked up readily with 21 per cent of water. The average air shrinkage was 6·6 per cent, and the average tensile strength when air dried was 25 pounds per square inch. It had enough plasticity to flow through a tile die. The shale burns to a red colour, which increases in depth with the intensity of the firing. The bricklets are steel hard at cone 05, and practically vitrified at cone 1. The burning tests were as follows:

Laboratory Sample No. 1920.

Cone	Fire shrinkage %	Absorption %
010	1·0	9·02
05	2·7	7·75
1	4·7	2·30
3	fused	

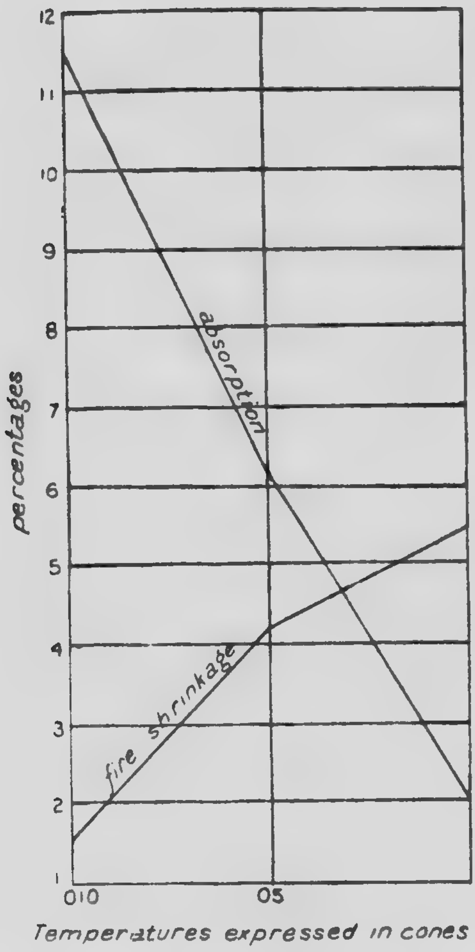


Figure 15. Shrinkage and absorption curves of shale, Laboratory Sample No. 1921, Passburg, Alberta.

These tests are shown graphically in Figure 16.

The shale would probably work for paving brick, as well as building brick.

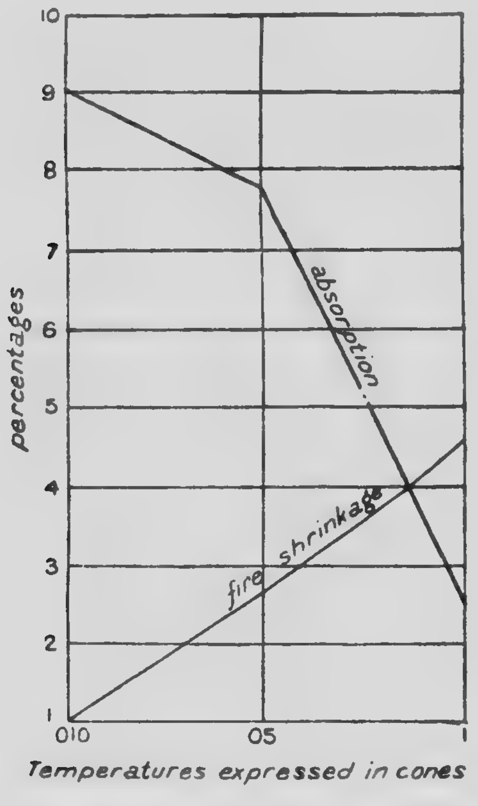


Figure 16. Shrinkage and absorption curves of shale, Laboratory Sample No. 1920, Passburg, Alberta.

A fifth sample (Lab. No. 1938) is another shale of good plasticity, whose air shrinkage was 8·5 per cent. The shale burns to a brownish red colour and is steel hard at cone 05. The burning tests were as follows:

Laboratory Sample No. 1938.

Cone	Fire shrinkage %	Absorption %
010	1·0	11·98
05	1·7	9·24
1	3·6	4·16
3	5·0	3·40
7	nearly viscous	

Figure 17 shows the above graphically.

This is one of the most refractory of the Passburg shales tested, and in this respect resembles the next one. The bricklets had a good ring and colour even at cone 010.

The dry-press bricklets at cone 010 showed 12·58 per cent absorption, and 2·6 per cent fire shrinkage. They were a little soft for use. Those burned at cone 05 were nearly steel hard, with 11·07 per cent absorption.

A sixth sample (Lab. No. 1937) is of a clay shale which andy and of low plasticity. It does not work as well as ·36 for example, and yet no trouble was experienced in wet-moulding it, nor in forming it into dry-press bricklets. The average air shrinkage of the wet-moulded shale was 7 per cent. It burns to a red body, which is steel hard at cone 05. The absorption is moderate, and the fire shrinkage is low up to cone 05. These facts were borne out by the following tests of the wet-moulded bricklets:

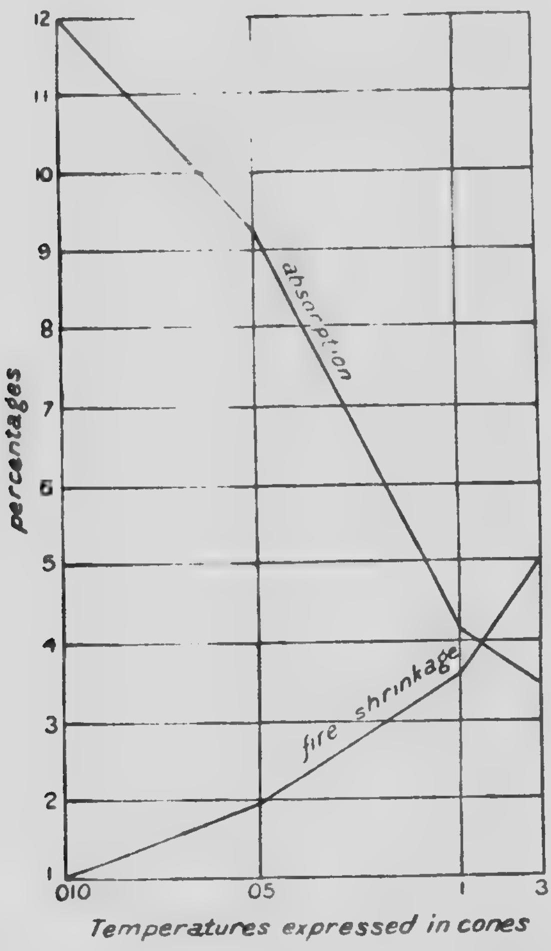


Figure 17. Shrinkage and absorption curves of shale, Laboratory Sample No. 1938, Passburg, Alberta.

Laboratory Sample No. 1937.

Cone	Fire shrinkage %	Absorption %
010	1·3	15·91
05	2·0	14·20
1	6·0	2·93
3	8·0	1·50
7	viscous	

The dry-press bricklets were too soft for use at cones 010 and even 05, but at cone 1, they were hard, with a fire shrinkage of 7·6 per cent and an absorption of 3·3 per cent.

Comments on Passburg Shales.

The tests made on the shales from Passburg are interesting. They are all plastic. Four of them soften at a comparatively low cone, while the other two stand a much higher heat. It seems that the best plan to adopt would be to make a mixture of the two classes, as the shales of higher heat resistance would serve to hold the mixture up in burning.

I believe that the shales contain good possibilities. Most of the shales are sufficiently plastic to flow through a die. They burn to a good red dense body, with low shrinkage and low absorption. Those of lower fusibility could be used for common or pressed brick, drain tile, or, I believe, for fireproofing. A mixture of the two classes of material could probably be used for paving brick, and possibly sewer-pipe. In the latter case, the more refractory of the shales should form two-thirds of the mixture.

SOUTH FORK, ALBERTA.

In the report covering the field season of 1912, a number of tests were given of some clays obtained by Mr. J. D. Mackenzie of the Geological Survey, from near Jackson creek, a branch of the South Fork river, in the NE. ¼ sec. 23, tp. 6, range 3, W. 5th mer. These clays according to Mackenzie,

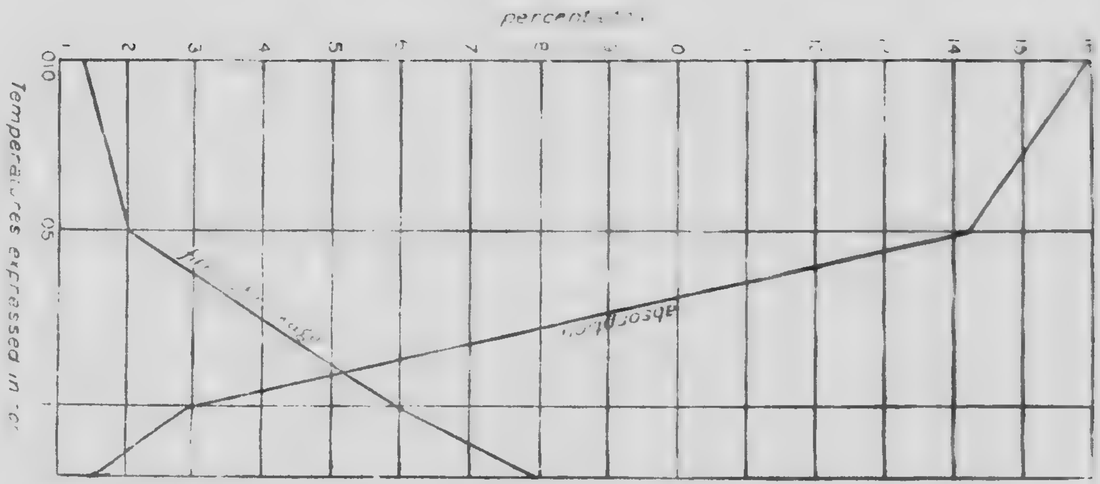


Figure 18. Shrinkage and absorption curves of shale, Laboratory Sample No. 1937, Passburg, Alberta

lie in the Benton, and are folded into an overthrown syncline, the underlying volcanics being well exposed (Plate VIII A) both up and down stream from the shales. The clay occurs in beds from 4 to 8 feet thick, interbedded with dark carbonaceous shales. The shales show considerable disturbance, as a result of which the clay beds pinch and swell. A small stream cuts across the strike of syncline, and it is on the sides of the small valley made by it that the prospecting for clay has been done. Owing to a heavy covering of stream gravel which appears first on one and then the other side of the gulch, exploration for the clay has been rendered somewhat difficult.

Following up this small tributary valley, one comes first to the volcanics which form the lower limb of the syncline (Plate VIII A). These are very gritty and of no value for the manufacture of clay product. At one point a stream of spring water has trickled down over the volcanic rock, and decomposed it, so that a thin layer of clayey material can be scraped off, but there is not enough of it to be of any value.

Following up the valley a few hundred yards, the west side is gravel covered, while the east side is uncovered. Here, three openings have been made on the hillside. The lower opening is near the stream level, and shows the greyish clay, with a hanging-wall of dark shale. The material (Plate VIII B) appears to be slightly faulted. A second opening lies about 50 feet up the hill side and west of south from the lower pit. A third opening has been made at about the same level as the second, but north of east from the first or lower one. The bed exposed in the second opening appears to dip towards the first and the two may belong to the same bed. In both the second and third openings there is a hanging-wall of dark shale, and in the third opening the foot-wall is also seen, showing a thickness of not over 8 feet, with the beds dipping northwest.

The western or second pit is represented by Lab. No. 1925 and the third pit by Lab. No. 1929. In each case the samples were taken by sectioning across the bed of clay. The clay in the second pit had some scattered nodules of lime carbonate.

A few hundred feet farther up the stream, the shales form a steep outcrop on the western side of the bank. Here the

strike is N. 60 degrees W., and the dip about 65 degrees N. A cut about 18 feet high has been made exposing the clay which is of irregular thickness and confined between walls of carbonaceous shale.

Just across the stream from this outcrop there is a low bench of soil and dirt, and then the gravel bank rises steeply to the rim of the valley. Several test pits and other holes have been put into the gravel bank, in an effort to pick up the clay along its line of strike on the east side of the valley, but at the time of my visit none of these had penetrated through the gravel.

The first factor to be considered here is the location of the deposit and its possible structure. The variation in thickness seen in the cut farthest upstream and the disturbed nature of the clay in the lowest of the group of three openings justify the belief that the clay beds may be rather irregular in their thickness. The fact that the shales containing the clay are bent into a syncline, of probably no great size, speaks for a limited depth on the dip. These facts coupled with the narrowness of the beds do not argue for a large supply, sufficient to support an extensive plant. How far the clay extends on the strike is not known, as outcrops are scarce.

The clay would have to be worked entirely by underground methods, such as drifts run along the strike, or as the owners suggest, by a tunnel at right angles to the strike, from the valley below. This tunnel would probably strike the clay low down in the syncline.

The two samples collected were carefully tested, to form some definite idea of their value.

Sample No. 1929 was a yellowish grey clay, of calcareous character which worked up to a moderately plastic mass with 30 per cent of water. The average air shrinkage was 8 per cent and the average tensile strength 35 pounds per square inch.

Wet-moulded bricklets were made to determine the shrinkage and absorption in burning, with the results shown following:

Laboratory Sample No. 1929.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·3	17·88	buff
05	1·3	14·00	buff
1	4·0	9·72	buff
3	5·0	9·8	buff

The wet-moulded bricklets were steel hard at cone 05. The brick burned at cone 010 and had a good ring; but since those tested from this locality last year air slaked after burning at this cone, the present ones were carefully watched. They were first dried on a radiator for 24 hours, and then placed in water for another 24 hours without showing any signs of disintegrating. While the clay burned buff up to cone 3, it turned bluish grey above that, or even at cone 1 if burned in a reducing fire.

Dry-press bricklets were also tried. One burned at cone 010 was speckled pink, had a fire shrinkage of 3 per cent, and an absorption of 15·97 per cent A second dry-press sample fired at cone 05, showed 4·5 per cent fire shrinkage, and 9·7 per cent absorption. The body was buff in colour, and steel hard. The surface of the brick was not very smooth, due to granular fusible impurities.

Clay No. 1925 was similar in appearance to 1929, showing the same granular character, and being slightly more calcareous. It yielded a very plastic mass with 28 per cent of water. The average air shrinkage was 6·9 per cent, and the average tensile strength 50 pounds per square inch.

The clay burns buff up to cone 1, unless exposed to a reducing fire, when it turns grey. It became steel hard at cone 05, but should not be burned at a lower cone, such as cone 010, because of its tendency to air slake. The bricklets fired at 010 disintegrated almost completely after standing in the laboratory for about a week. If burned harder the body is sufficiently bonded by vitrification to prevent disintegration, and moreover the lime fluxes in part with the surrounding particles of the clay.

Tests on the bricklets are given below:

Laboratory Sample No. 1925.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·0	——	buff
05	0·6	19·48	buff
1	1·3	15·62	buff
7	Fused		

Dry-press bricklets fired at cone 1 in slightly reducing fire, had a fire shrinkage of 0·7 per cent, absorption of 13·70 per cent, and grey colour.

Both these clays could be used for making buff or blue-grey pressed brick, but it is questionable whether they would be of much use for other kinds of burned clay wares. I cannot regard them as of value for pottery since much better pottery clays are to be obtained elsewhere in the western provinces.

The deposits are somewhat remotely located from the railway, but one could be constructed into this district without serious difficulty.

JASPER PARK, ALBERTA.

In last year's report a description was given of a cream-burning, calcareous lake clay that was found at the coal mines at Pocahontas, Alberta. This year a sample of similar material was sent in by G. Conway Brown, from the same district.

The clay is very plastic, but typical of clays containing a large quantity of lime carbonate, and is not a fireclay. It has an air shrinkage of 7·5 per cent and burns to a cream-coloured brick, of high absorption. At cone 010 the fire shrinkage was zero, and the absorption 28·20 per cent. At cone 05, it still had zero fire shrinkage, and an absorption of 27·61 per cent. At cone 1, the fire shrinkage was 2·7 per cent, and absorption 27·60 per cent. At cone 3, the clay was nearly viscous.

The clay could be used for making common brick, and possibly even drain tile, although the latter, of course, could not be vitrified. In its general characters it resembles many of the calcareous brick clays used in Manitoba.[1]

COCHRANE, ALBERTA.

A sample of very plastic clay was sent to the Geological Survey by Dr. T. G. Ritchie of Cochrane. It was found on the SE. ¼ tp. 26, range 4, W. 5th mer. Nothing is known regarding the extent of the deposit.

The material (Lab. No. 1948) is a dark grey calcareous clay, that worked up to a mass of excellent plasticity with 19 per cent of water. The average air shrinkage was 7 per cent, and the average tensile strength 155 pounds per square inch when air dried. The clay flows well through a tile die. The burning tests on the wet-moulded bricklets were as follows:

Laboratory Sample No. 1948.

Cone	Fire shrinkage %	Absorption %
010	0·45	18·70
05	0·85	18·10
1	4·00	2·65
3	Nearly fused	

The clay although calcareous is not sufficiently so to yield a buff or cream colour after burning, and there is enough iron as compared with lime to colour it red.

The material is to be classed as a brick and tile clay. It could probably be worked dry-press if burned hard enough. The bricks would be too porous if burned at a low cone.

[1]See Ries and Keele, Can. Geol. Surv., Memoir 24 E, p. 18 et. seq. 1912

and
ould
any

cal
he
d-

us
9
t,
h
e

SUMMARY OF TEST

Laboratory Number	Locality.	Water required per cent	Air shrink. per cent	Tensile strength lbs per sq in	010		05	
					Fire shrink.	Absorption.	Fire shrink.	Absorption
1942	Red shale, Blue mountain, B.C.	18	5	25	1	17·20	2	16·07
1943	Blue shale, " " "	25	8	25	2·8	17·60	4·4	15·55
1944	Grey " " " "	29	8·5	25	3·0	13·72	3·3	11·25
1943 and 44	Mixture " " "	....	6·6	35	3·0	12·50	4·4	11·25
1942 and 44	" " " "	....	5·6	....	....	....	5·4†	9·0†
1945	White clay, " " "	18	5	25	3·3	14·25	4·0	14·18
1928	Buff weathered shale, Gabriola island	22	7·6	....	1·4	13·43	4·4	9·18
1927	Blue, unweathered shale, " "	18	5·0	....	0·6	12·54	4·0	12·07
1933	West of Mudge is., near Nanaimo, B.C.	The shale cannot be wet moulded. Can be dry pressed, but not very satisfactory						
1931	Top clay, Empire coal mine, Princeton, B.C.	29	9·3	96	1·7	16·76	4·1	13·25
1919	Preheated clay cut near Cement mill, Princeton, B.C.	....	7	....	1	17·10	3·3	10·20
1950	Same locality, mixture 25% raw clay and 75% calcined clay	....	8	....	1·85	16·58	2·4	11·76
1951	Same locality. Equal parts calcined and raw clay	....	6·5	81	2·0	18·16	3·3	16·80
1934	Clay under upper coal, Princeton Coal and Coke Co., Princeton, B.C.	25	5·0	....	0·6	25·15	2·0	25·50
1932	Clay under lower coal same place	Cracked badly after preheating to 300°C.						
1935	Hanson brickyard, Cranbrook, B.C.	20	5·4	87	0	26·43	1	20·80
1941	Schist, Wyckliffe, B.C.	Plasticity too low to mould. Difficult to make cohere in dry pressing.						
1946	St. Mary river, 4 miles above Ste. Eugene Mission	29	4·2	57	2	27·6	5	25
1930	1 mile northeast Canyon, B.C.	23·8	3·1	25	0	18·6	1	16·2
1924	Goat Canyon station, B.C.	30·8	4·9	45	0	25·8	0	24·0
1923	Between Creston and Goat canyon, B.C.	35	7	90	0	26·4	1·5	23·50
1940	2 miles west of Coleman, black shale	Does not work plastic. Can be dry pressed.						
1922	" " shale	Difficult to dry press. No plasticity.						
1926	" shale near waterfall	22	4·3	20	0·8	18·20	1	15·12
1949	Mixture of 1926 and 1940	14	4	25	0·5	15	1	14·10
1936	Passburg, Alberta	25	8·7	....	1	10	3	7·43
1939	" "	23	7	....	0	11	1·8	8·5
1921	" "	22	6·6	30	1·6	11·46	4·2	6·18
1920	" "	21	6·6	25	1·0	9·02	2·7	7·75
1938	" "	....	8·5	....	1	11·98	1·7	9·24
1937	" "	....	7	....	1·3	15·91	2	14·2
1929	South Fork, southeast of Blairmore	30	8	35	0·3	17·88	1·3	14
1925	" " "	28	6·0	50	0·0	....	0·6	19·48
1948	Cochrane, Alberta	19	7	155	0·45	18·7	0·85	18·1
1947	Pocahontas, Alberta	25	7·5	....	0	28·20	0	27·61
1953	Giscombe Portage, B.C., 30 miles above Fort George, on Fraser river.	20	6	....	2·3*	17·10	3	15·4
11904		15	4	....	1*	14·0	1	14·0

†Cone 07.

F TEST… ON WET-MOULDED BRICKLETS.

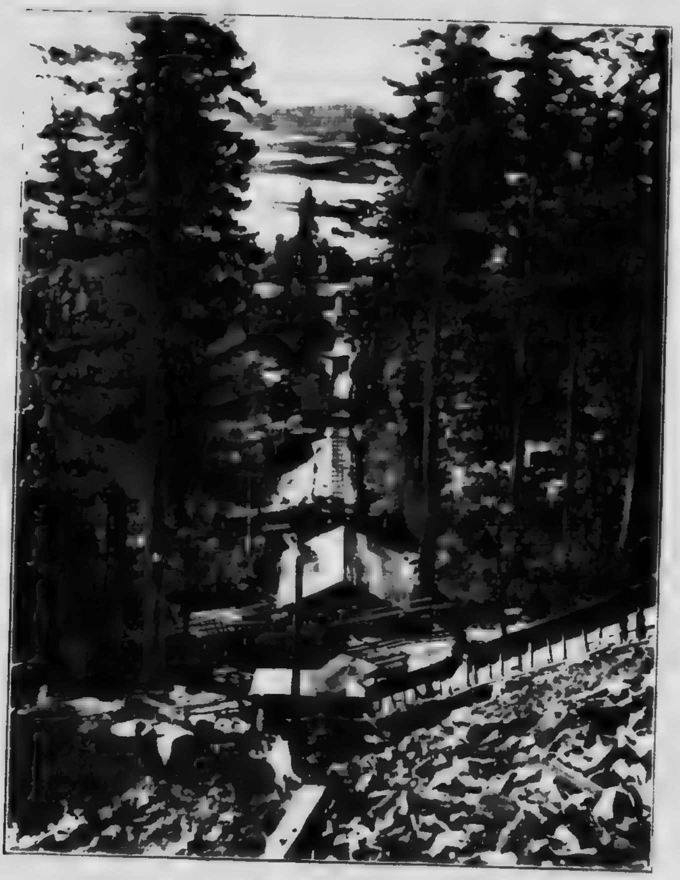
	1		3		5		9					
Absorption	Fire shrink.	Absorption.	Fire shrink.	Absorption.	Fire shrink.	Absorption.	Fire shrink.	Absorption.	Fire shrink	Absorption.	Colour	Recommended for and remarks.
16·07	5	13·63	4	6·90	5	1·28	Viscous				Red	Common brick. Face brick. Quarry tile. Works dry press.
15·55	5·6	10·35	....	....	7*	7·0*	7·4	5·1	11·5	2·6	Buff	Pressed brick. Fire brick. Terra-cotta. Fuses cone 30.
11·25	5·4	9·28	6·5	6·63	7	5·5	8·0	3·8	8·6	1·2	Deep buff	Pressed brick. Works dry press. Possibly sewer-pipe.
11·25	5·4	11·43	6·0	10·50	6*	9·25*	6·4	9·0	7·3	4·0	" "	Brick. Fireproofing.
9·0†	5·4	9·0	5·4	9·0	6	7·6	7·0	6·0	....		Red	Face brick. Fireproofing.
14·18	6·0	10·40	....	....	9·4	4·65	9·0	4·6	9·6	2·2	Cream	Face brick. Terra-cotta. Can be dry pressed.
9·18	7·4	0·78	Nearly fused		....		....	....			Red	Dry pressed brick.
12·07	5·0	2·49	5·0	3·0	....		....	....			Red	
sfactory							....	....			Red	
13·25	6·3	9·04	7·4	7·85	7·+	3·2		0·9	Nearly fused		....	Pressed brick.
10·20	7	6·10	....	....	....	....	....	....			Red	Can be used for red brick if preheated.
11·70	6·6	4·92	....	....	....	....	....	....			Red	
16·80	8·3	5·52	....	....	....	....	....	....			Red	
25·50	4·0	19·36	....	....	5·0	18·80	6	16·80			Buff	Tests made on preheated clay.
20·80	10·7	0·10	Fused		....	....	....	....			Red	Brick and tile. Will dry press.
25	11	8·8	13	0			....	....			Pink	
16·2	9·4	4·76	9·5	4·7	Nearly viscous cone 7.		....	....			Pink	
24·0	10·3	0·0	....	....	....	....	....	....			Pink	Common brick.
23·50	1·7	16·87	Fused		....	....	....	....			Red	Common brick and tile.
							....	....			Red	
15·12	1·4	14·73					....	....			Red	
14·10	1	11·12	....	....	....	....	....	....			Red	Will dry press also.
7·43	5·4	0·09	Nearly fused.		....	....	....	....			Red	Vitrified brick.
8·5	5	1·59	"	"	....	....	....	....			Red	" "
6·18	5·4	2·0	"	"	....	....	....	....			Red	Red brick; draintile; fireproofing.
7·75	4·7	2·3	"	"	....	....	....	....			Red	Paving brick.
9·24	3·6	4·16	5	3·40	Nearly fused at cone		7				Red	Will dry press.
4·2	6	2·93	8	1·5	" "	" "	....				Red	
4	4·0	9·72	5	9·8							Buff	Face brick.
9·48	1·3	15·62			Fused at cone		7				Buff	" "
8·1	4·0	2·65	Nearly fused		....	....		....			Red	Brick and tile.
7·61	2·7	27·60	"	"							Cream	Face brick and firebrick.
5·4	3·0	15·5	....	....	5·0	10·2	6·0	8·1			Cream	
4·0	1·5	13·5	....	....	2·5	11·0	2·5	9·5			Cream	

†Cone 07. *Cone 7.

EXPLANATION OF PLATE I.

Gravity plane and chutes, Kilgard, B.C.

PLATE I.



EXPLANATION OF PLATE II.

A. North end of shale bank, Dominion Brick and Tile company, Gabriola island near Nanaimo, B.C. Note the sandstone bed in shale.

B. Shale bank showing sandstone layers which have to be thrown out in quarrying the shale, Gabriola island, B.C.

PLATE II

A

B

EXPLANATION OF PLATE III.

A Shale bank on the south shore of Mudge island near Nanaimo, B.C

B. Sandstone outcropping just west of shale shown in A.

PLATE III.

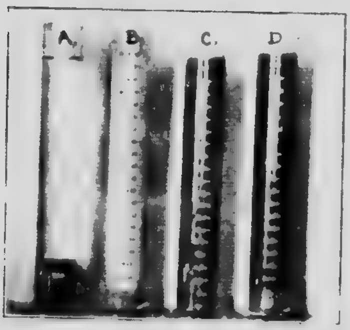
A

B

EXPLANATION OF PLATE IV

View of jars containing suspended clay after standing twenty days.

PLATE IV



EXPLANATION OF PLATE V.

A. General view of Hanson's brickyard near Cranbrook, B.C.

B. Clay pit at Hanson's brickyard near Cranbrook, B.C.

PLATE V.

A

B

EXPLANATION OF PLATE VI.

A. Pre-Cambrian metargillite along the track at Wyckliffe, B.C.

B. Clay cut at Goat canyon near Creston, B.C., on Canadian Pacific railway.

PLATE VI

A

B

EXPLANATION OF PLATE VII.

Shale bank and tunnel on G. H. Bradley's claim, 2 miles west of Coleman, Alberta.

Plate VII.

Explanation of Plate VIII.

A. View showing volcanics forming lower limb of overthrown syncline near South Fork. The Benton shales with grey clays underlie the ridge at rear.

B. Test pit along creek tributary to South Fork, on claims of Buckler and Diver. Light material is clay; dark rock is carbonaceous shale. There is probably a slight fault here.

PLATE VIII.

A

B

INDEX.

A.

B.

C.

H.

J.

K.

L.

M.

N.

O.

P.

Q.

R.

S.

T.

V.

W.

CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

MEMOIR 66

No. 54, GEOLOGICAL SERIES

Clay and Shale Deposits of the Western Provinces

(PART V)

BY
J. Keele

OTTAWA
GOVERNMENT PRINTING BUREAU
1915

1A

No. 1455

CONTENTS.

ILLUSTRATIONS.

INTRODUCTORY.

Developments have taken place so rapidly in late years over such large areas in the western provinces that it seemed advisable to give, if possible, general information regarding the clay and shale resources of the region as a whole, instead of confining the investigations to detailed work in any special portions. The present report and the accompanying report, as well as the three previous parts already published, are an attempt to give a general account of the distribution of the clay and shale deposits in the four different provinces, as well as all the information possible regarding the technology of these materials.

The investigations to be undertaken subsequently will cover in a more detailed manner those areas in which materials of exceptional value have been found to occur during the previous examinations, or those districts where industrial centres are likely to develop owing to economic reasons. Certain outlying districts which have hitherto been inaccessible, will soon be provided with railway communication, and their resources brought within the bounds of development.

Most of the materials reported on have been sampled by the writers in the field, but included in the present report are several tests on clay samples submitted from outside sources to the laboratory for examination. These materials were generally, small in amounts, and as a rule were not accompanied by any description of the extent or occurrence of the deposit from which they were taken. Such tests are generally of little value, as the sample selected may not give the true value of the average character of the deposit, or a sample may be taken from a deposit too small in extent to have an economic value in an industry.

Attention is directed to the chapter on drying of clays in this report. Many clays in the Great Plains region of western Canada have defective drying qualities, and the tests for drying should be one of the first points determined in their examination.

Considerable time has been spent by the writer in devising a method to overcome this defect, which will be practical in its application, and experiments with this end in view are still in progress.

EXPLANATION OF CONES.

Seger pyrometric cones were used for control of temperature in burning when making the tests for these reports. Their composition and use are fully described in Memoir 24. These cones are small triangular pyramids, about one-half inch in dimension at the base, and 3 inches long, tapering to a point. The cone bends in time, under the influence of heat, until the point touches the base which supports it when placed opposite the peep-hole in the kiln. The bending of the cone is an indication that the required heat, whatever it may be, has been arrived at and firing is stopped. Two or three cones, with softening points 20 degrees C. apart, are generally set up in a row, when used in practice. This is the simplest and cheapest method of obtaining and controlling kiln temperatures.

Pyrometers are also used in most of the larger plants. The following is a partial table of cone numbers, and their equivalent softening points in degrees. It will be found useful for reference in connexion with this report.

No. of cone.	Fusing point.	
	Degrees F.	Degrees C.
010	1742	950
09	1778	970
08	1814	990
07	1850	1010
06	1886	1030
05	1922	1050
04	1958	1070
03	1994	1090
02	2030	1110
01	2066	1130

No. of cone.	Fusing point.	
	Degrees F.	Degrees C.
1	2102	1150
3	2174	1190
5	2246	1230
7	2318	1270
9	2390	1310
10	2426	1330
12	2498	1370
15	2606	1430
20	2786	1530
25	2966	1630
26	3002	1650
27	3038	1670
30	3146	1730
31	3182	1750

The cones used in the different branches of the clay-working industry in the United States and Canada are approximately as follows:

Common brick....................	012–01
Paving brick......................	01–5
Sewer-pipe........................	1–7
Buff face brick..................	1–9
Hollow blocks and fireproofing......	07–1
Terra-cotta.......................	02–7
Conduits..........................	5–8
Firebricks	5–14
White earthenware...............	8–9
Red earthenware..................	010–05
Stoneware.........................	6–8
Porcelain..........................	11–13
Electrical porcelain...............	10–12

Clay and Shale Deposits of the Western Provinces.

PART V.

CHAPTER I.

MANITOBA.

PLEISTOCENE.

Sprague.

Five samples of clay from a farm in this vicinity were submitted to the laboratory for testing. No data regarding the thickness of the deposit, or character of overburden, if any, were sent. Four of the samples were nearly alike in character, being taken from different pits, and may be treated as one. They were yellowish, sandy, calcareous clays, requiring 20 per cent of water for tempering. Their plasticity was fairly good so that they could be made up into smooth, hollow, round tile in a hand press. Their drying qualities were not good, it requiring about 5 days to dry a full sized brick at room temperature; if forced to dry at a faster rate than this, the brick will check, and becomes useless. The drying shrinkage is from 5 to 6 per cent. These clays burn to a salmon coloured rather porous body at cone 06, with an absorption of 18 per cent. When burned to cone 1 the body is buff coloured, and denser, the absorption being 13 per cent. There is no shrinkage in burning; on the contrary, a slight swelling takes place during this operation; this being a frequent occurrence with clays having a high lime content.

These clays will make very good buff-coloured building brick by the soft-mud process, and it is possible that hollow brick or drain tile can be made by stiff-mud machine. The drying is their weak point, but by slow drying and protection from hot winds, they can be dried intact.

In order to secure a hard durable product, the burning must be carried to the temperature of cone 1 or nearly so. The clay contains enough small lime particles to cause underburned wares made from it to disintegrate; hence it is an unsafe material to use unless fully burned.

These clays, in general, are similar to those worked for brickmaking at Morris, Winnipeg, and Balmoral, and are representative of the brick clays of the Red River valley, in Manitoba, as described in Memoir 24.

The fifth sample submitted from Sprague was a stiff, highly plastic and sticky, bluish grey clay, which underlies the yellow calcareous clay. It burns to a dense red body at low temperatures, and is non-calcareous. This material is of no value for brickmaking purposes, as it cracks badly in drying, warping, and shrinking to a high degree as well during this process.

A similar clay underlies all the buff-burning clays, at the other localities mentioned above.

Winnipeg.

The material used for brickmaking in the vicinity of the city of Winnipeg consists of about 3 feet of buff-burning clay. Underlying this thin sheet is about 40 feet of red-burning blue clay, which is unworkable in the raw state on account of its extreme toughness, stickiness, and tendency to crack and warp in drying. Many attempts have been made to utilize this clay but without success.

The ante-fired process has been suggested as a possible means of overcoming this obstacle to using it. This consists in calcining the clay, as it is dug from the pit, in roast heaps, using either wood or coal for fuel. The calcined clay is then ground in dry pans to pass a 12 mesh sieve. The ground, burned clay is mixed with 5 or 6 per cent of hydrated lime, and

pressed into brick shapes, which are hardened in a cylinder under steam pressure. The process is similar to that used in the manufacture of sand-lime brick. The resulting brick has the colour of the burned clay and is much more porous than a sand-lime brick.

Some test brick were made by this process in the laboratory and submitted to crushing and freezing tests. The results of these tests showed that the nature of the bond produced was as good as that in sand-lime brick.

A method of using the clay in the raw state may be obtained by the use of caustic lime. The addition of about 3 per cent of this ingredient has a remarkable effect. It destroys the stickiness, reduces the plasticity, makes the wet body workable, and assists in dryir As far as the experiments in the effects of quicklime have proceeded, they show that while the clay may be rendered workable by its use, it seems to cause a weakening of the burned body. It also increases the tendency towards scumming.

Mafeking.

A sample of yellow surface clay from the lower slopes of Porcupine mountain in the vicinity of Mafeking was sent to the laboratory for examination. This is a highly calcareous, gritty clay which required 30 per cent of water for tempering. It is fairly plastic but works rather short, being liable to tear in moulding. It burns to a salmon-coloured porous body at cone 06, but becomes buff-coloured when burned to higher temperatures. The clay contains enough coarse lime particles to cause the underburned wares to disintegrate in time, due to air slaking of the lime. It would be suitable for the manufacture of common brick if burned to a temperature between 2000 degrees and 2100 degrees F.

CRETACEOUS—PIERRE AND NIOBRARA.

Shales of Cretaceous age extend from the Pembina river at the International Boundary, northwestward along the base of the Pembina, Riding, Duck, and Porcupine mountains.

In Manitoba this system contains in ascending order the Dakota, Benton, Niobrara, and Pierre. The general characteristics and several tests of these materials are given in Memoirs 24 and 25.

Virden.

The Pierre shales which occur on the upper part of east Assiniboine hill about 4 miles north of Virden, were reported on a few years ago. This shale is non plastic when finely ground and mixed with water, so that it cannot be moulded into shape. It burns to a red colour and to a light weight porous body at all temperatures up to cone 5. This is the most refractory material at present known in the province, as it is not fused at cone 15 (1430 degrees C.) requiring a rather higher temperature to do so; but it is not a fireclay.

Some samples were received for testing recently from this neighbourhood, but higher up the valley of the Assiniboine, the locality given being the S.E. ¼ of sec. 14, tp. 11, range 25. The samples were taken from pits in the valleyside, one at 15 feet below the prairie level, and another at 150 feet below. Both of these samples were dark grey, rather soft and flaky shales, entirely different from the Pierre shales described above, being highly plastic, sticky materials, when ground and tempered with water. They burn to a dense body with a red colour at low temperatures, but the test pieces bloated unless fired very slowly. They also have a large drying shrinkage, accompanied by warping and cracking, even in the small bricklets.

These shales by themselves do not appear to have any value for the manufacture of clay products, but a small quantity of them might be mixed with the non-plastic Pierre shales to render the latter workable in wet-moulded processes.

Another sample was a light greenish grey, soft material taken from a test well sunk by the town of Virden within the town limits. This well passed through 65 feet of surface clay, sand, and gravel, and at 70 feet below the surface struck a thin layer of the substance referred to. This was probably bentonite or soap clay, an exceedingly plastic, fine-grained material,

mostly colloidal matter. It has a small commercial value when in large quantities, easily accessible. It is described in Memoir 25, page 89.

Leary.

Leary is a station on Pembina mountain on the line of the Canadian Northern railway. A dry-pressed brick plant has been in operation here for some time; it is described in Memoir 24. An effort is now being made to utilize the shale of the Niobrara formation in this vicinity for the manufacture of sewer-pipe. Two carloads of the shale were shipped to the Ontario Sewer Pipe company's works at Mimico for the purpose of making a test on a commercial scale. It is a soft dark grey, almost black shale, containing particles of gypsum and some carbonaceous matter. It burns to a dense red body at cone 03, and begins to soften at about cone 6. The shale grinds easily and is very plastic, coming from the pipe presses with a smooth polished black surface. Its drying qualities are good.

The product turned out of the kiln at the end of the burning was fairly satisfactory for a first trial. On account of the carbonaceous matter, and the gypsum which this shale contains, the burning of wares made from it will be attended by some difficulty. Better results could probably be obtained by mixing some Pierre shale with the Niobrara. The effect of the Pierre shale is to make the mixture more refractory, and give a body which is not quite so dense as with Niobrara shale alone. Such a body would be much easier to burn the carbon from, and reduce the tendency towards bloating and black cores. The quality of the salt glaze produced would also be better on this mixture. This fact was pointed out in Memoir 25, page 93.

Carmen.

A plant for the manufacture of clay products is being erected at Carmen, the clay to be used is that described above from Leary, and coal will be brought from the nearest available field. The advantages of this point are a cheap factory site and good facilities for distributing finished products, as three

different lines of railway touch here. Fireproofing, hollow blocks, and sewer pipe will be manufactured at this plant.

Mafeking.

Two samples of soft, dark grey or black shales received for testing from Porcupine mountain, near Mafeking. No information was sent regarding the thickness of the beds nor whether the deposits could be easily worked. These shales may belong to the Benton division of the Cretaceous, but they resemble the Niobrara shales to some extent. They are quite plastic when ground and mixed with water, one of the samples being quite pasty, and stiff in working. The small test pieces dried without cracking, but full sized pieces probably give some trouble in drying. They burn to light weight, porous, red bodies at cone 03, and melt about cone 4. If burned too fast they swell up into a vesicular mass which will float in water. These shales contain so much carbonaceous matter that they burn with a bright flame like bituminous coal when heated to 500 degrees C.

Test pieces made by the dry-pressed process, had a black core and cracked surface when burned. Whatever else these shales may be adapted for, they do not appear to be of any use for the manufacture of clay products.

DEVONIAN.

The Devonian rocks occur in a narrow strip, extending north from near the International Boundary along the shores of Lakes Manitoba and Winnipegosis. Argillaceous beds are comparatively rare in this formation in Manitoba, the greater part of it being composed of limestone.

German Hill.

The only sample of Devonian shale so far tested in the province was collected by Mr. A. MacLean, of the Geological Survey, from a thick bed at German hill, on the south shore

of Lake Winnipegosis. This shale is light red or salmon-coloured, but contains grey rock particles which are probably from thin limestone bands interbedded with the shale. The deposit as a whole is highly calcareous, and is soft and crumbles down at the outcrops. When ground and tempered with water it has good plasticity and works rather smooth. It burns to a cream-coloured soft body like chalk, which falls to pieces very quickly from air slaking. This happens after the material has been burned to 2000 degrees F. It is impossible to use it for the manufacture of clay products, on account of the high percentage of lime it contains.

SILURIAN.

The Silurian rocks cover a rather larger area than the Devonian, and lie principally between Lake Winnipeg and the other large lakes to the west. They are the principal source of the building stone for the city of Winnipeg.

Stonewall.

About 6 feet of red and grey, hard, calcareous shales underlie the lower beds of magnesian limestones or dolomites in the quarry at Stonewall. An average sample of these beds was collected for testing by the writer.

When finely ground and worked up with 14 per cent of water this material developed a fair amount of plasticity, which was unexpected in such a gritty material. It could be moulded into 3 inch round pipe in a hand press. Its drying shrinkage was 3 per cent. It burns to a cream-coloured, soft body with a slight increase in volume, at all temperatures up to cone 3. The absorption at this point was excessive, being about 35 per cent. The shale stands a high degree of heat, probably on account of a large percentage of magnesia, and it does not vitrify until cone 8 is reached. At a little higher temperature than this it will melt suddenly. This material contains such a high percentage of lime that it cannot be burned to a dense body at ordinary temperatures, hence it could not compete with the

surface clays of the vicinity, such as those at Balmoral, which burn dense at comparatively low temperatures, and which require no preliminary grinding.

Another bed of shale 10 to 18 inches in thickness occurs 6 feet higher up in the same quarry. The percentage of lime in this bed is also very large, some of it being present in rather coarse particles, after grinding to pass a 20 mesh sieve. This shale works up into a very plastic body when tempered with water. It burns to a cream-coloured chalky body, which rapidly disintegrates in air, and is useless for the manufacture of clay products.

CHAPTER II.

SASKATCHEWAN.

PLEISTOCENE CLAYS.

City of Saskatoon and Vicinity.

The city of Saskatoon and vicinity is underlain by unconsolidated surface deposits, or drift, of unknown depth. The Saskatchewan river has cut a trench to a depth of about 100 feet in the drift materials, without reaching bedrock at any point in this neighbourhood. A boring made while prospecting for gas, near the Grand Trunk Pacific Railway bridge, revealed the fact that soft dark grey shales of Cretaceous age underlie the surface drift. A sample of this shale taken from the borehole was tested, but it proved worthless for the manufacture of clay products.

The surface deposits consist essentially of two classes of materials: (1) boulder clay, (2) surface clay. The boulder clay is the lowest member of the drift series; it is a direct glacial deposit, consisting of a heterogeneous mixture of large and small well rounded boulders, pebbles, gravel, and sand embedded in a matrix of clay.

The main portion of the city is built on the boulder clay, which forms the low terrace on the west side of the river (Plate I). Most of the large boulders found strewn along the margin of the river at low water stages, are derived from this deposit. These boulders have been largely utilized for building stone in the city; further than this the deposit has no economic value.

The surface clay which overlies the boulder clay, appears to have been deposited in water having more or less current. It consists of a mixture of silty or sandy yellowish clay, with a dark grey, stiff, highly plastic clay. These two materials are irregularly distributed through the deposit, so that they cannot

be separated in working. Occasionally they alternate in horizontal or wavy bands and layers, but the dark clay mostly occurs in lenses or pockets in the silty yellow clay (Plate II A).

As far as could be ascertained in the limited time at my disposal, this type of clay is the only kind available for the manufacture of structural wares within a radius of at least 4 miles from the city.

Exposures on the western side of the Saskatchewan river showing good sections of the surface clays were seen at Elliott's brickyard, in the Canadian Pacific Railway cutting on the Cahill farm, and the Grand Trunk Pacific Railway cutting near the bridge. On the eastern side of the river the material was seen to advantage in the excavation made for the foundations of the Presbyterian college, and at several points on the cut banks of the river.

This clay possesses certain disadvantages which are readily apparent to the clay worker. (1) The stiff dark clay which may be called by the expressive name "gumbo" is hard to work. It does not slake in water, nor mix with the accompanying silty clay in the pug-mill, but remains in lumps. These lumps act like pebbles in the burned brick, being a source of weakness when large in size. (2) The clay is hard to dry after it is moulded into shape. It has to be handled carefully and slowly during the drying process or the wares will crack. (3) Its softening point under firing is low, so that it can only be used for the common kind of brick, but not for the manufacture of vitrified wares.

The first of these difficulties may be overcome by drying the clay in storage sheds, and grinding it fine in the dry state. This method is effectual in giving an even distribution of the gumbo through the mass, and producing a more uniform body. No machine has yet been devised that will grind the gumbo as it comes wet from the bank.

The drying difficulty is not so easy to overcome. The clay when made up into brick by the soft-mud process can be dried intact on racks and pallets set outdoors, if they are protected from warm winds during the early stages of drying. It would be harder to dry brick made up by the stiff-mud or wire-

cut process, owing to the denser body in this class of ware. Porous fireproofing or drain tile may be easier to dry than brick, owing to the comparatively thin walls in these wares. In making any class of wares, however, hurrying the drying process would probably result in serious losses.

The clay may be rendered more workable by the preheating process, which consists briefly in passing the clay through a rotating cylinder and applying a heat of 400 degrees to 500 degrees C. The preheating of the raw clay destroys the stickiness, and makes it easier to dry. A clay that cracks can be changed to a fast drying clay by this treatment. As the Saskatoon clays are of low grade, suitable only for the manufacture of common brick, it is doubtful if this method could be applied economically.

The addition of sand would assist the drying, but as the clay burns to a rather porous body, the sand would tend to weaken it. A better plan would be to grind up waste brick to add to the clay, as this would not interfere with the density or structure of the burned body

Tests of the Clay.

A sample was taken from the cutting on the Grand Trunk railway, about half a mile east of the river. About 20 feet in depth of clay is exposed here, consisting of sandy or silty clay, with layers or wavy bands and pockets of stiff dark clay irregularly distributed.

The clay contains a rather high percentage of lime, effervescing violently in dilute hydrochloric acid. There are no pebbles or coarse grit particles present. This sample (Lab. No. 142) was ground fine enough to pass through an 8 mesh screen, and tempered with 23 per cent of water. It formed a very plastic rather sticky mass, but will pass through a lubricated machine die without tearing.

A 3-inch cube made up for a drying test, cracked at a temperature of 80 degrees F. A full sized brick was placed to dry in the room temperature of 65 degrees to 70 degrees F. It requires 7 days to dry, without cracking. The drying shrink-

age was 7 per cent. The dried brick showed the grains of gumbo, which had not slaked during the tempering or moulding.

The clay burns to a pale red colour at cone 010, without any fire shrinkage, the body was very porous, the absorption being 18 per cent.

When burned to cone 06 (1880 degrees F.) the colour is rather deeper and the body denser, the absorption being 14·7 per cent. The brick becomes steel hard at this temperature.

If burned to cone 03 (2000 degrees F.), the absorption is reduced to 9 per cent, the fire shrinkage is 1·4 per cent, and the colour a little better. The clay melts at cone 3 (2174 degrees). The colour is not good at any stage of burning, although the brick at cone 06 were burned in a down draft kiln at the Don Valley brickworks at Toronto, under partly reducing conditions which ought to develop the best red colour in clay, if it is red-burning. The colour is obscured by the unsightly dirty white scum, which is due to a soluble salt of lime or magnesia brought to the surface during drying.

This clay is suitable for the manufacture of common brick, if made by [illegible] soft-mud process. On account of the drying difficulty t[illegible]ud or wire-cut process is not recommended, as bricks m[illegible]his process are harder to dry. If the clay is used direct[illegible] as it comes from the bank and simply passed through a pug-mill to the machine it will make brick similar to those produced in Mr. Elliott's brickyard, which is the best that can be done under these [illegible]nditions. The lumps of gumbo, which appear like pebbles, can be seen in these brick. The gumbo has a higher shrinkage than the silty clay, so that it draws away from the body and produces lines of weakness.

If the clay is ground when dry, the gumbo is uniformly distributed throug[illegible] mass, and the burned product is sound in structure, if fired to a temperature not less than 1850 degrees F.

A small sample for testing was taken from the highest part of the bank of the Saskatchewan, at the cemetery, on the east side of the river. This clay (Lab. No. 141) does not contain nearly so much gumbo as the other sections seen in the city. When tempered with 22 per cent of water, it forms a fairly plastic and easily worked body. It contains no pebbles or

fine grit. This clay was not tested for fast drying, as the sample was too small. The drying shrinkage of the bricklets made from it was 6·5 per cent.

It burns to a red colour at cone 010, with a hard body, and an absorption of 13 per cent. At come 06 (1880 degrees F.) the colour is a very fair dark red, with a steel hard body. The fire shrinkage is zero, and the absorption 11 per cent. When burned to cone 03 (2000 degrees) a fine clean dark red colour is produced, the body is very hard and dense, the fire shrinkage being 1 per cent, and the absorption 9 per cent.

This is the best brick material of any of the clays examined. The colour is good, and free from the objectionable scum which develops on the others. It produces a sound hard body, well adapted for weight carrying purposes in large structures.

The next sample was taken from W. O. Miller's farm about 15 miles southwest of the city of Saskatoon, on the bank of the Saskatchewan river. This property is situated on the flood-plain of the river, the level of the plain being about 15 feet above medium stage of water. The clay here consists of re-worked surface materials deposited by the river, during flood time. The river has since cut down through it. The material is very sandy, and contains no gumbo. It is highly calcareous.

This clay (Lab. No. 143) when tempered with 23 per cent of water, works up into a short rather flabby body of medium plasticity. It differs greatly from the stiff, sticky, gumbo clays, and will stand fast drying. The drying shrinkage is about 4·5 per cent.

It burns to a salmon coloured body at cone 010 (1842 degrees F.), very porous, but hard. When burned to cone 06 (1880 degrees F.) the body is still very porous, the absorption being 18 per cent. The fire shrinkage is zero. If burned to cone 03 (2000 degrees F.) the body becomes denser, but the absorption is still high—13 per cent, and the colour changes to buff. The clay melts at cone 3 (2174 degrees F.). The full sized brick submitted was burned in a down draft kiln at the works of the Don Valley company of Toronto.

This material will make common brick by the soft-mud process. It has the merit of standing fast drying without

cracking, but the colour is poor and the body rather light and porous.

A material which resembles marl was seen on the shore of Pike lake about 22 miles southwest of the city of Saskatoon, and also on John Forbes' farm about 2 miles nearer town. The material is light grey in colour, and contains numerous shells. It is not a marl, however, as the content of lime (only about 15 per cent) is too low: some small brick of the material were made and burned. A soft crumbling body resulted in burning, which was too weak to be of any use. This material appears to have no economic value, and only occurs in thin layers.

Floral.

A plant for the manufacture of common brick by the stiff-mud process was in operation at this point for the first time during the summer of 1913. It is situated on the Canadian Pacific line, about 6 miles east of the city of Saskatoon.

About 10 to 12 feet of clay is exposed in the pit excavated for brickmaking (Plate III). It is a stratified deposit, of yellowish colour with occasional streaks of exceedingly stiff dark grey material. Small particles of gypsum are scattered through the deposit, but there are no pebbles or coarse grit.

The clay works well and flows through the die of the machine in a smooth bar which is cut by the wires into an almost perfect brick. The drying qualities of the clay are poor, all attempts to dry the green brick without cracking having failed up to the time of my visit in August. The plant is equipped with a Betchel dryer, but the brick cracked in this dryer even when no heat was admitted. A sample of clay taken from this locality burned to a good red colour and hard body at 1850 degrees F., but it was impossible to dry any large sized pieces made from it. There is no sand in the vicinity of the plant, and it is doubtful if the addition of sand would improve the drying, unless by using a large quantity, which would weaken the burned body too much. The pre-heating treatment seems to be the only remedy for overcoming the difficulties in this clay, but it is not of high enough grade to warrant the expense of this treatment.

The tests of the clay were made for the Company that erected this plant, by a firm of clayworking machinery makers in the United States, and the sample brick submitted were satisfactory in every respect. No guarantee, however, was given that the plant could produce similar brick under working conditions.

Davidson.

A sample of Pleistocene clay was received from this point on the Regina branch of the Canadian Northern railway from the manager of the Davidson Clay Products company. This clay is very plastic and has good working properties; it is free from pebbles and coarse grit, but contains numerous crystals of selenite. It burns to a fairly hard red body at low temperatures, but it cracks so badly in drying that it cannot be used for brickmaking by any of the ordinary processes, even with the addition of 33 per cent of sand.

An effort will be made to use his clay by what is known as the ante-fired process, which consists in first calcining the clay in heaps as it comes from the bank, using either wood or coal for fuel. The calcined [illegible] ground in dry pans, mixed with a small percentage of lime, then pressed into brick shapes, which are hardened in cylinders under a pressure of 120 pounds of steam. It will be noted that the method of procedure after the burned clay is ground is the same as in making sand-lime brick. This process is in the experimental stage at present, but it may provide a means of working those clays that crack in drying.

Bruno.

A small brick plant for the manufacture of common building brick was erected at this point on the Canadian Northern railway in 1913. A sample of the clay to be worked at this locality was submitted to the laboratory for examination. It is a yellow-coloured, highly calcareous clay, apparently free from pebbles or coarse particles. When tempered with 25 per cent of water, it works up into a mass of fair plasticity. The shrinkage on drying was 5 per cent. The fast drying qualities are not

good, but it can be dried slowly with safety. It behaves as follows in burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0	27	salmon
06	0	29	salmon
03	1	25	buff
1	1·3	22	buff

It is a typical calcareous clay, burning to a soft pink porous body at lower temperatures, becoming slightly denser and buff-coloured when burned higher. A good common brick made by the soft-mud process can be made from this clay, but they must be burned nearly to cone 1 (2100 degrees F.) in order to secure the best results.

Kamsack.

The plant of the Kamsack Brick and Tile company is situated about a mile east of the town on the Canadian Northern Railway line. The clay is taken from the sloping ground of a small river valley. It is a yellowish stratified clay, 8 to 10 feet in thickness, fairly free from pebbles. It is overlain by 1 or 2 feet of gravelly clay, and underlain by Cretaceous shale which is described later on.

The clay requires 24 per cent of water for tempering; its plasticity and working qualities are fairly good. The drying shrinkage is 6 per cent, and the drying must be done slowly, as the clay is liable to crack if forced. The results obtained in burning are as follows:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·2	23·8	light red
06	0·2	22	light red
03	1·5	18	buff
1	4	12	buff
3	softens		

This clay will make good common brick by the soft-mud process, but it must be burned to a temperature of not less than 2000 degrees F. (cone 03), otherwise the brick will be too soft, and unsafe for use. Its lime content is rather high, so that it melts rapidly soon after vitrification begins, but it is not necessary to burn to a higher temperature than cone 1 (2100 degrees F.).

A good rule to observe in working these calcareous clays is to produce a good strong yellow colour in the burned product. The pink colour is an indication of underburning. When carbonate of lime exists in coarse particles or pebbles in a clay, they are usually fatal to the permanency of the brick made from it, but hard burning reduces the loss from this source.

LARAMIE FORMATION.

The Laramie formation underlies a large triangular area in southern Saskatchewan. The base of this triangle forms the southern boundary of this province, as far west as the Wood Mountain district, which is included in it. From the apex of the triangle a narrow belt extends northwestward to a little beyond the main line of the Canadian Pacific railway west of Moosejaw. This area includes the Souris coal fields and the Dirt hills. Detached areas are found north and west of this, where the Laramie formation occupies the summits of some of the plateaus and portions of elevations such as the Cypress hills.

This area is of importance because it contains at many localities white or light grey sandy fireclays, and other deposits of a similar nature, which do not stand quite so much heat, called semi-refractory clays. The fireclays of this region have fusing points between cone 27 (1670 degrees C.) and cone 32 (1750 degrees C.), while the latter fail in the fire tests at cone 15 (1430 degrees C.) to cone 25 (1630 degrees C.).

Certain deposits of these types have been described in the two reports on western clays already published. Some additional localities discovered during the season of 1913 are given in the following pages, along with other deposits of less

value, from the same formation. Most of the samples referred to were collected by Mr. Bruce Rose, of the Geological Survey. Further details concerning the extent and relationship of these deposits will be given in his report on the geology of the region.

Brooking.

This (170) is a greyish white soft clay containing an abundance of fine-grained grit. This clay requires 21 per cent of water for tempering, and works into a very plastic body with good working qualities. Its drying shrinkage is 5 per cent, and its drying qualities appear to be good, but this test was not made as the sample was too small.

Cone.	Fire shrinkage. %	Absorption. %	Colour.
06	0·3	15	buff
1	1·6	13	buff
3	1·6	12·2	cream
5	2·3	12	grey
10	4	3	grey
20	fused		

This clay behaves like a fireclay in burning up to cone 5, the body remaining open and the shrinkage low. Numerous fused specks appear on the surface of the test pieces when burned to cone 10.

Although this is not a refractory material, it is nevertheless a valuable clay. It can be used for high grade face bricks, or stove linings. It would probably take a salt glaze and be used in the manufacture of sewer-pipe, or electrical conduits, but would have to be burned to a rather high temperature to secure the necessary density of body. If mixed with a certain proportion of good red, dense burning clay, the temperature of burning for vitrified wares could be reduced, and products made with less expense. It is not quite clear from the description whether this deposit occurs in a workable position, or is of suf-

ficient thickness. The locality given for it is sec. 30, tp. 6, range 18, W. 2nd mer. and near the branch line of the Canadian Northern railway.

Big Muddy Valley South of Bengough.

The valley of the Big Muddy river lies 10 to 12 miles south of Bengough station, on a branch of the Canadian Northern railway. This river has cut down through a series of horizontal beds of clays, sands, and lignites, which are exposed on the steeper sides of the valley (Plate IV). A white sandy clay containing rust coloured lumps, which farmers in the vicinity use as a plaster, occurs near the bottom of the bank. This clay (172) requires 24 per cent of water for tempering, it is very plastic, stiff, and pasty in the wet state. It dries slowly and exudes soluble salts which form a slight scum. The drying shrinkage was 7 per cent. The small test pieces did not crack, but full sized wares may crack in drying. The following results were obtained in burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour
06	1	12	salmon
1	2·4	8	pink
3	3	7	buff
5	4	5·6	grey
10	4	0	grey
20	fused		

The body is vitrified, develops fused spots on the surface, and becomes slightly vesicular at cone 10. This clay is not so sandy as 170, consequently the shrinkages are greater and it burns to a denser body. It is probably suitable for the manufacture of sewer-pipe, but its drying qualities would have to be carefully tested before a decision to this effect could be made. It works well in the dry-pressed process, and should give a good buff or flashed colour, with a hard body when burned to

cone 1. It belongs to the semi-refractory class of clays, and is not a fireclay. A similar clay is said to outcrop at several places along the bottom of the valley of the Big Muddy river. The position given for the above deposit is sec. 31, tp. 3, range 24, W. 2nd mer.

Overlying the white or light grey clays are a series of lignite seams and beds of grey and brownish clays and sands. A sample was taken from one of the clay beds, which had a thickness of 43 feet at this locality. It is a soft, fine-grained, grey clay, containing limonite concretions. It makes a stiff sticky paste when tempered with water. The small test pieces cracked so badly that the test could not be proceeded with. The addition of sand does not cure the tendency to crack, so that the material appears to be useless for the manufacture of clay products, in the raw state. The pre-heating process might be applied to stop the cracking, but as the clay is an easily fusible and rather low grade variety the expense of this treatment would be too great.

A bed of grey sand, 34 feet in thickness, overlies this clay. This sand is actually plastic, forming a rather sticky mass when tempered with 30 per cent of water. It is easily moulded, but the small test pieces crack badly in drying, and burn to a wea red body, which is easily crumbled. The greater part of this deposit is composed of sand grains, mostly quartz, a large percentage of which are coarse enough to remain on a 100 mesh sieve. The small proportion of clay in this mass has the power to cause plasticity, and cracking in drying. It is a natural example of the futility of trying to stop the cracking of some of the Laramie clays of this region by the addition of sand.

Coal Mine Lake, Near Bengough.

About 2 feet of soft grey shale underlies the coal seam at this locality. This clay is highly plastic and sticky, with poor drying qualities. It burns to a dense hard red body at cone 06 with a total shrinkage of 12 per cent, which is excessive. This clay is of little or no value.

Underlying this clay is a bed of yellow silt (179) which works up into a body of rather low plasticity when tempered with water. It has a drying shrinkage of 6 per cent, and can probably be dried safely, without cracking. It burns to a light red, porous but sound body at cone 06, without any fire shrinkage. This material is suitable for the manufacture of common red brick by the soft-mud process. The locality given for these clays is sec. 3, tp. 5, range 23, W. of 2nd mer.

Big Muddy P.O.

Sec. 9, tp. 1, range 22, W. 2nd mer

A sample of rather hard grey shale (171) which lies on top of a 3-foot coal seam was collected at this point. This clay requires 30 per cent of water for tempering, it is very plastic, smooth, and sticky. Its drying shrinkage is 8 per cent. The small test pieces did not crack in drying, but it is probable that full sized pieces of ware might do so.

It burns to a light red body with rather high absorption at cone 06, and is fused to a slag at cone 3. If the drying difficulty can be overcome, this shale would make good common brick. About 25 per cent of sand could be used to reduce the air shrinkage. It is not a fireclay, nor is it suitable for the manufacture of vitrified wares.

Willowbunch Lake.

(Sec. 35, tp. 5, range 26, W. 2nd mer.)

A bed of massive, fine-grained, grey clay occurs overlying a coal seam at this point. A sample of this clay (177) required 36 per cent of water for tempering. It formed a very plastic sticky mass but the working qualities were fairly good. This clay will probably crack in drying when made up into full size wares, but the test pieces did not. Its drying shrinkage is excessive, being 9 per cent. It burns to a steel hard, light red body at cone 06, the fire shrinkage being 2 per cent, and the absorption 15 per cent. It vitrifies at cone 2, and begins to soften about cone 5. When made up by the dry-pressed process, this clay burns to a very fair red colour, and hard body at cone 06.

The shrinkage is rather high, and the drying qualities poor, otherwise this is a very good, red burning clay. It would be useful to mix with some of the sandy fireclay that occurs in this district, for the purpose of making sewer-pipe or fireproofing.

Verwood.

A bed of dark grey, soft shale, or hard clay occurs in sec. 28, tp. 7, range 27, W. 2nd mer. This clay requires the large amount of 45 per cent of water to bring it to a working consistency. It is a very fine-grained material, exceedingly plastic, stiff, and pasty and hard to work in the wet state. It cracks in drying. It burns to a red colour with an excessive shrinkage, and softens at cone 5. It is not a fireclay, and would be a difficult material to handle for the manufacture of any kind of clay product.

A bed of greyish clay 15 feet thick occurs on the Weyburn-Lethbridge line of the Canadian Pacific railway a short distance west of Verwood station. It is overlain by 11 feet of sand. This clay works up so stiff and cracks so badly in drying that it is useless. The addition of sand does not overcome these defects.

Lake of the Rivers.

Deposits of white sandy clay are situated near the north end of Lake of the Rivers, near the Expanse branch of the Canadian Pacific railway, and also near the Avonlea branch of the Canadian Northern railway. Some lignite seams also occur in this vicinity. A sample of the clay was collected by Mr. Rose, the locality given being sec. 14, tp. 11, range 28, W. 2nd mer.

This is a white sandy clay (178), the sand portion is composed of small rounded quartz grains with an occasional scale of white mica. It requires 20 per cent of water to bring it to a good working consistency, its plasticity and working qualities are good. Its shrinkage on drying is 5 per cent, and will probably stand fast drying. Its behaviour in burning is as follows:

Cone.	Fire shrinkage %	Absorption. %	Colour
06	0	13·8	buff
1	0·3	12	buff
4	1	11·5	cream
5	1	10	grey
10	2	6·4	grey
26	fused		

This material is almost refractory enough to be a fireclay, only failing at 40 degrees C. below the requirements of that class It stands considerably more heat than 170 or 172, and may be used for many purposes where the demands for refractoriness are not very exacting. It is a valuable clay in the district in which it occurs, and when used alone, or in a mixture with more easily fusible clays, will produce a large range of clay products for structural purposes.

There appear to be two or more beds of clays similar to the above in this locality, as samples from another source were sent to the laboratory for examination, which were said to have come from the same deposits on the Lake of Rivers.

These were greyish white, sandy clays, but not quite so clean in appearance as 178. Both these clays were fused at cone 20, so that they are semi-refractory clays and stand a high degree of heat, but they are not fireclays.

The following chemical analysis made by W. S. Bishop, B A., shows the composition of the two samples of clay from Lake of Rivers:

	1.	2.
Silica (SiO_2)..............	68·17	66·30
Alumina (Al_2O_3)...........	21·76	19·02
Iron oxide (FeO)	1·98	5·60
Lime (CaO)...............	0·22	0·11
Magnesia (MgO)...........	0·72	0·60
Alkalis (Na_2O+K_2O)......	1·20	not determined
Loss on ignition...........	6·07	7·29

These clays can be used for the manufacture of sewer-pipe and face brick or fireproofing, when mixed with a proportion of more easily fusible clay or alone. There is not much demand for fireclay in Saskatchewan, a clay that works well, dries easily, and with a good range of vitrification in burning, is far more important at present in that province.

Mullrany.

(Sec. 6, tp. 6, range 27.)

A sample of dark grey, hard clay was collected from this locality by Mr. Rose. This is a very fine-grained, highly plastic clay, absorbing the large amount of 44 per cent of water in tempering. It is very stiff and pasty in working, hard to dry, and has high shrinkages. It burns to a hard red body at low temperatures, and begins to soften about cone 3.

On account of poor working and drying qualities, together with abnormally high shrinkages, this clay is not of much value.

Another sample of clay, collected at a point a short distance west of the above, the locality given being sec. 12, tp. 6, range 30, W. 2nd mer., was also tested. This was a grey calcareous rather silty slay, containing rusty lumps. It requires 25 per cent of water for tempering, it worked up fairly plastic, but was rather flabby in the wet state. It is one of the few clays in this region that will stand fast drying by artificial heat, which is probably owing to its lime content as well as to its silty character. The drying shrinkage is 5·5 per cent. It burns to a fairly good light red or salmon-coloured body at cone 06, with an absorption of 11 per cent, and melts to a slag at cone 4. This clay is suitable for the manufacture of common building brick.

Mortlach.

About 7 miles south of Mortlach, on the southwest quarter of sec. 17 tp. 16, range 1, W. 3rd mer., a bed of grey, smooth clay was discovered outcropping on the side of a coulée. It is overlain by a thin seam of lignite, and several feet of glacial stony clay. A shaft which was sunk on the property in search

of coal is said to have passed through a thickness of 9 feet of this clay. This clay (153) is very fine-grained and highly plastic when wet, and of a dark grey colour, but bleaches to nearly white when dry. Its shrinkage on drying is rather high, being 10 per cent. The following results were obtained on burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
06	1·3	15	cream
03	3·0	13	buff
1	3·0	12	buff
3	3·6	8·4	buff
5	4·3	7·5	grey
10	3·0	vitrified	grey
20	fused		

This material resembles a stoneware clay, but the shrinkage is rather too high for use in the manufacture of stoneware pottery. It stands a fairly high degree of heat, being a semi-refractory clay. It is probably suitable for a high grade face brick made by the dry-pressed process. It would also be useful as one of the ingredients of a sewer-pipe body.

East End.

A small sample of white or light grey clay collected on the bank of Frenchman river, a few miles south of East End, was submitted to the laboratory for examination. No information regarding the thickness of the deposit or its overburden was given. It was a very plastic, smooth clay with good working qualities. It burns to a light grey colour with a vitrified body at about cone 5, and is fused at cone 15. It is one of those semi-refractory clays of the stoneware type.

The white or light grey clays on the Frenchman river and Farwell creek, south of the Cypress hills, were described in the Geological Survey reports nearly 30 years ago. On account of their remoteness from any lines of transportation these clays

have hitherto been inaccessible. The Weyburn-Lethbridge branch of the Canadian Pacific railway now under construction will shortly place these clays at the disposal of clay-workers.

Sa 'chewan River.

There is a small d[illegible] area of the Laramie formation lying just north of the Saska[illegible]ewan river, southwest of Elbow. A small sample of clay from this area was received at the laboratory, the locality given being sec. 17, tp. 21, range 10, W. 3rd mer.

It was a light grey, plastic clay which burned to a grey colour and vitrified body at cone 10, and fused at cone 20. It belongs to the group of semi-refractory clays found in southern Saskatchewan, resembling No. 170, from [illegible]rooking. No information was given about the extent of the deposit. It appears to be situated at a considerable distance from a railway.

NIOBRARA SHALE.

Kamsack.

The Niobrara shale is found underlying the surface deposits and also exposed at a few points along the Canadian Northern railway, a short distance east of the town of Kamsack. It was uncovered in the bottom of the clay pit of the Kamsack Brick and Tile company, when the surface clay overlying it was removed for brickmaking purposes. The shale is brownish in colour when near the surface, but is dark grey below. It contains a large quantity of selenite or gypsum crystals scattered irregularly through the deposit. The Niobrara shale is soft and can easily be dug out with a spade, but it is much tougher to work in than the overlying Pleistocene or surface clay. This shale when ground and mixed with water forms a pasty mass of high plasticity, which is stiff and hard to work. It shrinks greatly and cracks in drying. It burns to a hard red body at low temperatures, but will swell or bloat unless fired very slowly. If made up by the dry-press process, the drying difficulty is

overcome, but the bricks will check in burning. On account of its poor drying and burning qualities this material is not recommended for the manufacture of clay products.

Swift Current.

There are numerous exposures of Niobrara shale in the terrace along the west bank of Swift Current creek, just north of the town, beginning near the hospital. It is dark grey in colour and soft, and may easily be mistaken for a surface clay at the outcrops. It contains a considerable quantity of gypsum in rosettes and flaky slates. This shale is highly plastic and pasty when ground and tempered with water, being also exceedingly stiff and hard to work. It cracks badly in drying, even the small test pieces made from it cracked at ordinary room temperature shortly after being moulded. It burns to a steel hard, red body at cone 010, with a high shrinkage, and melts at about cone 3. This shale is defective in the three most important qualities a clay must have for successful manufacturing, viz., working, drying, and burning.

CHAPTER III.

ALBERTA.

PLEISTOCENE.

There is a large area underlain by stratified Pleistocene clay in central Alberta. It is worked for brickmaking at Lacombe, Red Deer, and Innisfail. It reaches a depth of 40 or 50 feet in places, but its thickness is very uneven as it is laid down on a hummocky surface of boulder clay. Knolls of boulder clay occasionally rise to the surface.

Bullocksville.

There are some good exposures of this clay in the cuttings along the Canadian Northern railway, between Bullocksville and Alix and along the valley of Haynes creek in this vicinity. The deposits generally consist of soft, yellowish, silty layers, interlaminated with harder grey layers of stiff clay. There are occasional bunches and streaks of gravel, but these could be avoided in mining the clay.

An average sample was taken from a bank about 20 feet high in a railway cutting near Stone siding (Plate V B). The clay contains a small percentage of finely divided lime, but no coarse particles or lime pebbles were found in the portion sampled. This clay requires 24 per cent of water for tempering, it works up into a very plastic wet body. Its drying shrinkage was about 8 per cent, which is rather high, but this could be reduced by the addition of about 25 per cent of sand. It behaves as follows in burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·0	18·7	light red
06	0·3	18·5	light red
03	7·0	3·0	red
2	fused		

The clay burns to a good hard body at cone 010, but the colour is better and the body denser at cone 06. The fire shrinkage becomes too great if burned to a higher temperature. The drying qualities of the clay were not tested, but it could probably be dried safely on rack and pallets. It could be used for the manufacture of common brick, by either the stiff-mud or soft-mud process, the latter being the easier to dry. The proper temperature of burning is about 1850 degrees F. The burned bricks become coated with an objectionable white scum, which obscures the colour of the red body.

Mirror.

A small sample of clay from this vicinity was submitted for testing, by Mr. Alex. Mather. It was a buff-coloured, slightly calcareous gritty clay, containing particles of gypsum. It was very plastic, and rather sticky when tempered with water. Its drying shrinkage was only 5 per cent, but its drying qualities were not good. The clay burns to a dense steel hard red body at cone 010, without any fire shrinkage. It stands firing to a higher temperature than the clay from Bullocksville, as it is not softened at cone 1. It is a very good common brick clay, and might also be used for the manufacture of hollow building blocks, if the drying could be accomplished safely. No statement was given regarding the extent of the deposit.

Innisfail.

Common brick are made at this locality by the Innisfail Brick Company (Plate V A). The clay bank at the brick works shows alternate bands of sand, silty clay, and stiff clay, in horizontal layers of 6 inches to 1 foot thick. A proper mixture of these materials seems to make an excellent building brick. There does not appear to be much trouble from cracking in drying, as the green brick come intact from a steam dryer. The brick are made by the stiff-mud process, end cut, some of them being made hollow for partition brick. The burning is done in 3 updraft rectangular kilns, with permanent side

walls, the fuel used being dry poplar. The greater part of these brick are sold in Edmonton, and are probably the best common brick made at present in the province of Alberta from surface clays.

Belvedere P.O.

Two small samples of clay from this locality, in tp. 58, range 3, W. 5th mer., were submitted to the laboratory for testing. One sample was a yellowish non-calcareous clay, which was very plastic and stiff and hard to dry in the wet state. It has a large drying shrinkage, and dries very slowly. It burns to a dense steel hard body at cone 010, and fuses at cone 2. This clay will make good common brick, with the addition of 25 per cent of sand, if the drying difficulty is not too great. The other sample was a yellow gritty calcareous clay, not very plastic when wet. This clay swells slightly on burning and gives a very porous chalky body, as the percentage of lime is rather high. When underburned it has a salmon colour, turning to buff when fully burned. It would make a common brick of doubtful quality. A mixture of these two clays would probably give better results than either of them used alone.

Stettler.

The town and surrounding district of Stettler is underlain by Pleistocene clay which for the most part is of glacial origin. Pebbles are scattered freely throughout parts of the clay, but large patches are fairly free from them. A small quantity of red brick were made two years ago at the east end of the town, near the crossing of the Calgary branch of the Canadian Northern railway. A small sample of clay for testing was collected at the roadside about half a mile west of the town. This clay appeared to be free from pebbles, but a section only a few feet below the surface was seen. The clay cracked so badly in drying, that it could not be burned. It is quite probable that the clays in this vicinity are to a large extent defective in this respect.

Vegreville.

Two large samples of clay, taken from different depths to 12 feet below the surface, were submitted for testing by the Vegreville Brick company. Both samples are brownish, non-calcareous, very sandy clays, but free from pebbles of coarse grit. The upper part of the deposit is more sandy than the lower, otherwise it is much the same in character, so that they may be treated as one. The clay is very plastic, but not excessively so, and its working qualities were very good. The shrinkage in drying is about 7 per cent, and the drying qualities are poor. It burns to a very clean red hard body at cone 06, and should produce a good building brick when burned to that temperature. Brick made by the stiff-mud or wire-cut process from this clay would be hard to dry, but soft-mud brick could probably be dried slowly if protected from hot winds on racks and pallets. The clay will crack badly if forced in drying. Some dry-pressed test pieces were made up from this clay, but the results of the burned trials were not very good, as the brick were too soft and porous. Very few Pleistocene clays are suitable for the manufacture of pressed brick.

Medicine Hat.

A new brick plant owned by the Medicine Hat Brick company was built during the summer of 1913 on the site of the old Purmall and Pruitt brickyard (Plate VI B). This plant is designed for a large output of common wire-cut brick. A huge Bonnot special machine with a two-stream, end-cut die, having a capacity of 200,000 brick a day, was installed. A Williams clay crusher will be used to prepare the stiff clay which occurs in their bank. Tunnel driers, heated with gas furnaces, and provided with fan draft are used for drying the brick. The plant will be driven by electricity obtained from the city power house, about 550 horse-power being required for full running capacity. The burning is done in a series of updraft, cased kilns fired with natural gas (Plate VI B.) The source of the raw material is the high bank against which the plant

is built. It consists of a mixture of very stiff clay or gumbo with silty clay and sand mixed together in irregular layers and pockets. The gumbo clay when used alone is very stiff and hard to work, it has a tendency to crack in drying, and has a very high air shrinkage. It burns to a steel hard body with fairly good red colour at cone 010, and softens at cone 1.

The silty clay is easy to work and dry, but makes a rather porous weak brick. These clays are so irregularly distributed in the bank that it is impossible to mine them separately. The gumbo clay remains in lumps after being passed through rolls and pug-mill, and does not break down and mix with the other clay so as to give a uniform body. The William clay crusher is said to overcome this difficulty, and to deliver the material to the pug-mill in a thoroughly pulverized condition. A machine that will pulverize wet gumbo as it comes from the bank will be a valuable addition to the clay workers equipment in the west. There will doubtless be many difficulties of a technical nature to deal with before this plant is running smoothly to full capacity.

Pottery Works at Medicine Hat.

The most important recent addition to the clay working industries at Medicine Hat is the works of the Medicine Hat Pottery company (Plate VII B). This plant is erected and equipped for the manufacture of stoneware goods. A large quantity of these articles were turned out during 1913. These consist of churns, butter crocks, milk pans, jugs, and jardinieres. The stoneware clay used at this plant is all brought by rail from the Spokane district in the state of Washington. Some attempts have been made to use the clays from Dunmore and Redcliff, but they all proved too impure, and too easily fusible, besides having very serious drying defects.

The ordinary Bristol and Albany slip glazes are used, but some experiments have been made with local clays for this purpose. The trials so far made show that a light brown or yellowish glaze can be obtained from a washed clay that occurs in the vicinity of the works.

This local clay is also used for making flower pots. It burns to a red-coloured, smooth body at a temperature of 1850 degrees F. The pottery company is searching for a clay in western Canada, which would meet their requirements, but so far they have not found a suitable material. They have not as yet tried the stoneware clays that occur in the Dirt hills in southern Saskatchewan, but it is probable that these clays will upon trial prove to be the best material in the region for their purpose.

EDMONTON FORMATION.

The numerous tests that have been made by the writer on the clays and shales of this formation, have failed to reveal any satisfactory material for use in the manufacture of clay products, except the shales at Entwistle, described in Memoir 25, page 49. Most of these clays are exceedingly plastic, with very high shrinkages, they burn to a red colour, and develop an objectionable white scum on the surface of the burned ware. Their most serious defect is cracking in drying, a difficulty not easily overcome even by using the dry-pressed process.

The clay beds of this formation are associated with lignite seams, sands, and soft sandstone. The irregularity in bedding and the lack of continuity in the various members of this formation have been alluded to in former reports.

Nevis.

The presence of white clay in the Edmonton formation was discovered early in the autumn of 1912 by Mr. J. O. Williams of Camrose, and the locality was visited by the writer during the following year. The white clay is exposed at intervals along the line of the Lacombe branch of the Canadian Pacific railway, between Alix and Nevis, the sample collected for testing being taken from the north half of sec. 15, tp. 39, range 22, W. 4th mer.

The clay is exposed at the base of a low escarpment and in some outstanding buttes (Plate VII A); the generalized section in the locality being as follows:

	Feet.
Surface gravel	1
Grey sandy clay	10
Dark brown clay	20
White shale	2 to 4
Grey shale	3

The white clay or shale (144) is quite hard, and rather massive in structure, breaking down into irregular lumps. It is sandy in texture when dry, but when ground and mixed with 22 per cent of water it becomes highly plastic and even sticky. Its drying shrinkage is 6 per cent, but its drying qualities are poor. It behaves as follows in burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·0	14·0	
06	1·0	13·0	
03	2·3	9·4	
1	3·0	5·6	
3	3·7	5·6	
5	4·0	4·3	
10	Vitrified and slightly swollen.		
16	Softened.		

This material is not a fireclay, but it is by far the most refractory clay found up to the present in the Edmonton formation. Its poor drying qualities are against its use for any of the wet-moulded processes of clay working, but it might be used for cream-coloured or buff face brick when made up by the dry-pressed process. The deposit is not very accessible at this point as it carries too great an overburden of useless clay, but farther west nearer Nevis the white clay occurs nearer the surface. It also outcrops on the banks of Tail creek with a light overburden, and not far from the railway, but it does not appear to be in a bed much thicker than 4 feet at any point observed, although further prospecting may reveal a thicker deposit. The following chemical analysis of the white shale was made by Mr. Theo. H. Young of the Canadian Pacific laboratories at Winnipeg:

Silica	66·37
Alumina	26·62
Iron	1·28
Lime	0·42
Magnesia	trace
Alkalis	0·42
Sulphur trioxide	trace
Titanium	trace
Loss on ignition	5·15

The grey clay or shale which underlies the white shale is exceedingly plastic when ground and tempered with water. It cracks so badly in drying that even the small test pieces made from it could not be dried safely. Some dry-press bricklets made from it burned to a rich light buff colour, but were fire-checked.

On account of the heavy overburden, the thinness of the beds, and their defective drying qualities, these clays do not appear to have any economic value in the manufacture of clay wares.

The overlying grey and brown clays are very impure, possessing the excessive stickiness, high shrinkage, and poor drying qualities which unfits them for use. Some shallow test pits dug on the flat at the base of the escarpment have become filled with surface water and a yellowish paste or jelly like substance which appears to be bentonite or soap clay, described in Memoir 25, page 89.

The grey shale underlying the white clay contains a considerable amount of this material as it also forms a jelly after slaking in water. Silica in the colloidal form appears to be the jelly forming constituent and to cause the cracking in drying.

Castor.

Five small samples of different clays or shales from this locality were submitted for examination by the Coalbeck colliery. Four of these were hard and soft grey shales with rusty streaks, while one was of dark brown clay containing lignite particles. These are all highly plastic, stiff, pasty material when wet, and had bad working qualities.

All of the small test pieces made with the grey shales cracked badly in drying, even when mixed with 50 per cent of sand. They burn to a red colour, and are fused at cone 3. They would not be suitable for the manufacture of clay products unless treated in some manner to destroy the stickiness and tendency to crack. After treatment they might be used for the manufacture of common or dry-pressed brick or for fireproofing, but their softening point is too low to allow of their use for vitrified wares.

The test pieces made with the brown clay did not crack in drying. It burned to a good hard red body at cone 06, but it must be fired slowly or it will bloat, on account of the carbon it contains. This clay was fused at cone 5. Its drying qualities could not be tested, as the sample submitted was too small. Small test pieces will sometimes dry intact, when full sized ones made from the same clay will crack, owing to the thicker mass of clay that has to be dried.

TERTIARY FORMATION

This overlies the Edmonton formation, and forms a broad belt extending from somewhat north of the Grand Trunk Pacific railway, west of Edmonton, southward almost to the International Boundary. This formation consists of alternating beds of shale and sandstones, but outcrops are rather scarce as much of the area it underlies is covered by drift materials.

The shales of this formation are worked extensively for the manufacture of dry-pressed and wire-cut bricks in the Calgary district. A description of occurrences of shales with the results of tests at several localities in Alberta, is given in Memoir 24. Further investigation has resulted in additional data that follow.

Didsbury.

Various beds of shale, and one thin lignite seam, interbedded with sandstone layers, are exposed at intervals in the valleys of small tributaries of Rosebud creek, in this locality. An examination of these was made on the property of Mr. Wm. Hunsperger, which lies about half a mile south of the Canadian

Pacific Railway station. At this point a small stream has cut down a trench or coulée in the level upland, to a depth of 40 feet or more. The slopes of the coulée are mostly grassy or wooded so that it is impossible to get complete sections, without doing considerable stripping. As far as could be observed, beds of soft sandstone appear to constitute the greater part of the section. There are some fairly thick beds of shale overlying the sandstone, and other shale beds occur lower down in the bank which are covered with too great a thickness of stone to be accessible. The sections are very irregular, however, but it is possible that in some places the shale beds may thicken and form a workable deposit without having to mine too much sandstone.

One sample (148) taken from the top of the bank, represents an average of about 6 feet of dark grey shales. When finely ground and mixed with water, this shale had good plasticity, and working qualities. The drying shrinkage was 5 per cent, and the drying qualities are fairly good. It gave the following results on burning

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·0	14·7	red
06	0·0	14·0	red
03	2·4	9·2	dark red
1	6·0	0·0	brown
3	begins to soften		

This shale would work well by the stiff-mud process, and produce an excellent building brick at cone 06. If burned to a higher temperature it would yield a dense brick suitable for sewer linings. It also appears to be plastic enough to be used for the manufacture of fireproofing or hollow building blocks. When made up by the dry-pressed process and burned to cone 3, it makes a very good red face brick, with a strong dense body.

There are som[illegible] [illegible]rs of soft sandstone underlying this shale, a foot or so o[illegible] [illegible] in working and ground up with the [illegible] [illegible] plastic to hold more sand

Another bed of shale, about 20 feet lower down in the bank, was about 3 feet in thickness and overlaid a thin seam of lignite.

This shale (149) grinds easily, and requires 21 per cent of water for tempering. Its plasticity and working qualities are very good. It has good drying qualities, the drying shrinkage being 5 per cent.

It behaved as follows in burning:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·0	25	salmon
06	0·0	24	cream
03	0·3	21	cream
3	begins to soften		

This shale contains enough finely divided lime to cause it to burn to a cream colour, and porous body. It will make a good strong building brick when burned to cone 03 or higher.

An exceedingly fine face brick can be made by using a mixture of equal parts of this shale and the red-burning one just described. Some sample bricklets made of this mixture by the dry-press process and burned to cone 01, had an absorption of 16 per cent and were steel hard. The speckled colour of this mixture when burned was extremely effective. Rough-faced brick of various tones of colour can be made by the stiff-mud process from these shales.

Innisfail.

A thick covering of drift material almost completely conceals the character of the underlying bedrock in this vicinity. About 4 miles west of Innisfail, an outcrop of shale, about 15 feet thick, occurs on the south bank of the Red Deer river near the highway bridge. This shale is highly plastic and works well and burns to a bright red colour and dense body at cone 06, fusing about cone 4. It is a good brick or fireproofing shale, but has no commercial value owing to its location.

Macleod.

The stratified, stoneless, Pleistocene, brick clay appears to be absent in the immediate vicinity of the town of Macleod, the district being underlain by a thick deposit of boulder clay or by gravels. These superficial deposits effectually conceal the bedrock for the most part, as only one outcrop was seen during an examination of quite a large area. This consisted of a series of shale beds exposed on the south bank of the Oldman river, near the city stone-crushing plant in the town. The section as given below, shows the varied character of the shales in this district. It is measured from the top of the bank to the rivers edge.

	Feet	*Inches*
Coarse river gravels	14	
Dark grey, plastic shale	1	6
Shaly sandstone	2	
Mottled purple and green shale, very plastic	3	
Grey, sandy shale	2	
Dark grey, soft, crumbling, plastic shale	3	
Mottled green and purple shale, with lime nodules	2	6
Soft sandstone and sandy shale, with gypsum	4	

The heavy overburden of gravels renders this material inaccessible, otherwise all the shale beds above the one containing the limestone nodules, might be worked for brick or fireproofing.

Porcupine Hills.

The eastern escarpment of the Porcupine hills rises rather abruptly from the plains about 10 miles west of Macleod (Plate VIII A). No bedrock was observed on this plain (Plate VIII B) as it is covered by either stony clay or gravels, almost to the foot of the hills. The upper part of the escarpment appears to be

composed mostly of sandstone, the harder beds of which project in horizontal ledges, while the lower slopes are chiefly soft grey or reddish shales. Some small detached knolls near the junction of the plain and the hills are made up of banded pink, yellow, or grey clays, which outcrop in large patches.

An average sample of these vari-coloured clays was collected for testing, from the northeast quarter of sec. 17, tp. 9, range 27, W. 4th mer. This clay (150) requires 23 per cent of water for tempering, it is very plastic, and has fairly good working properties. The shrinkage on drying is 6 per cent, but its drying qualities are poor. It burns to a dense red body with buff specks at cone 03. On account of its poor drying qualities this clay is better adapted for use by the dry-press process, and will make a very fair light red face brick if burned to about 2000 degrees F. It is not adapted for the manufacture of vitrified wares as the fusing point of the clay at cone 3 is too low. This clay contains lime in coarse particles, and underburned products made from it will distintegrate on exposure to the weather.

A thick bed of plastic grey shale occurs higher up the slope of the hill, underlying a hard sandstone ledge. This shale was sampled in the hope that it might be a fireclay. It proved on testing to be a rather easily fusible, red-burning material, melting to a slag at cone 5.

The clays and shales in this locality are too far from transportation facilities at present to be of economic value.

BENTON SHALE.

Blairmore.

There is an abundance of dark grey, or brownish Cretaceous shales of the Benton formation in this locality. The best exposures are seen near the mouth of York creek, which cuts through these shales at right angles to the strike of the beds.

Four samples from different parts of these shales were collected at this point by W. W. Leach, of the Geological Survey. These four samples are so much alike in all respects that the tests for one of them will serve for illustration of the whole series.

The shales were ground to pass an 18 mesh sieve, and tempered with 17 per cent of water. The wet shale was very gritty to the feel, and its plasticity was so feeble that it was difficult to mould into shape. It can be dried as fast as desired; the shrinkage on drying is only 3 per cent. The burning tests are as follows:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	0·8	11·0	light red
06	0·8	10·0	light red
03	2·5	7·5	dark red
1	2·5	7·0	dark red
3	3·0	6·0	dark red
5	swells		

This shale contains a small amount of carbonaceous matter which will give trouble in burning unless fired very slowly during the oxidation stage. It takes a very bright uniform salt glaze at cone 4, so that it would probablt be suitable for the manufacture of sewer-pipe if the plasticity of the material could be improved. It is doubtful, however, if this could be done, unless by the addition of some highly plastic clay. Owing to its lack of plasticity this shale is best adapted for use by the dry-pressed process. It will make a good red face brick by this method if burned to about cone 02.

Sheep Creek.

A sample of light grey clay from the vicinity of Sheep creek was sent to the laboratory for examination. The locality given was tp. 21, range 3, W. 5th mer., which is rather vague, and no statement was sent regarding the extent of the deposit. The material is a light grey soft shale, with the appearance of a weathered talcose schist. When ground and mixed with 24 per cent of water, it was very plastic, rather smooth to the feel, but stiff and hard to work. Its drying shrinkage was 8 per cent; the drying qualities do not appear to be very good,

but the test pieces did not crack. It seems to have the necessary refractoriness for the manufacture of sewer-pipe, but the shrinkage is rather too high. Its tendency to crack would also be against its use for this purpose. If a certain quantity of the shale were calcined and added to the raw clay, both these defects could probably be overcome. The burning tests are as follows:

Cone.	Fire shrinkage. %	Absorption. %	Colour.
010	1·6	12·0	buff
06	2·0	10·0	buff
03	3·0	6·2	buff
3	4·0	4·8	grey
5	4·0	3·5	grey
11	fused		

When made up by the dry-pressed process and burned to cone 1, a face brick of fine buff colour and dense steel-hard body is produced. This material seems well adapted for this purpose.

CRETACEOUS.

Athabaska River.

The following notes refer to some samples of clay collected by Mr. Sidney Ells, who examined the tar sand deposits in northern Alberta during the summer of 1913.

It should be noted that the clays secured were merely small samples from surface outcrops. During the warm weather, bitumen and lighter oils seep out of the overlying tar sands and run down more or less over the underlying strata. It is, therefore, possible that the body of these clays may be free from the contamination that exists on the outcrops from this cause. An effort will be made to secure larger and more representative samples of these clays, during further exploration.

No. 187. This is a dark grey, almost black clay in a bed 12 to 15 feet thick, underlying bituminous sand on Moose river.

This clay is very plastic, fine grained, and smooth, it is rather stiff in working but not sticky. Dries very slowly with a drying shrinkage of 6·5 per cent. This clay contains so much asphaltic carbon that it is very hard to burn test pieces without swelling. The density of body due to the extreme fineness of grain of the material renders the burning-off of the carbon, during the oxidation stage, a tedious process. It burns to a light red colour at the lower temperatures and a buff or grey colour at higher heat. It vitrifies at cone 5, and fuses at the softening point of cone 20.

No. 188. This is a dark grey clay, exceedingly plastic and smooth, smelling strongly of asphalt when damp, collected on east bank of Athabaska river, about one-third of a mile above Fort McMurray. It burns to a light red colour at low temperatures, becoming grey when heated to about cone 5, and is fused at cone 16. Owing to its fineness of grain, and carbon content, this clay is very hard to burn without becoming bloated.

No. 190. This is a light grey, fine-grained clay from south bank of Muskeg river at base of bituminous sand; the deposit is at least 10 feet thick. It is a very fine-grained, plastic clay, which works up like a modelling clay. It burns to a steel hard cream body at cone 3, and does not begin to soften until the softening point of cone 27 is reached. This is the most refractory material at present known in the province of Alberta.

No. 191. This is a dark grey, very smooth, plastic clay, interbedded between bituminous sand and Devonian limestone on Moose river. It burns to a salmon-coloured dense body at cone 3, with a rather high shrinkage, and fuses at cone 18.

These four samples of clay are very similar in their physical characteristics, and appear to occur in the same geological horizon, viz., underlying the Tar Sands. They are very fine-grained sediments, comparatively low in fluxing impurities, and are more refractory than any of the Cretaceous clays in southern Alberta, No. 191 being almost in the fireclay group.

The samples were too small in size to allow of any complete determinations regarding their working and drying qualities, but they appear to be free from the defects so common in Cretaceous clays farther south.

These clays are of the stoneware type, being very plastic and smooth, burning to a dense light coloured body at cone 5, and capable of retaining their shape when heated to a considerably higher temperature. Their most serious defect is the presence of asphaltic carbon, which renders the safe burning of wares made from them a difficult process. Nos. 190 and 191 appear to be free from this impurity. Owing to their position under heavy overburdens, and their remoteness from transportation facilities, it is doubtful if these clays can be utilized, at least for some time to come.

CHAPTER IV.

DRYING OF CLAYS.

The most serious difficulty encountered during the process of manufacture of clay wares in the Great Plains region of western Canada, occurs in the drying stage.

The defective drying qualities of many of the clays is undoubtedly a great obstacle to the development of the clay products industry, and several failures that have been already made are due to this cause alone. The writer has been working on methods of overcoming the tendency towards cracking for some time. The results published in Memoir 25, Chapter VII, contain an account of all the experimental work done up to that time. Some results of further work done along this line of investigation are given in this chapter for the first time. The methods usually adopted in dealing with this trouble are briefly as follows.

ADDITION OF NON-PLASTIC INGREDIENTS.

More than 50 per cent of sand is usually required to overcome cracking in drying, with these clays. This amount of sand does not always improve the working qualities of the clay, and the burned body with such a mixture is too weak to be of any practical value.

By substituting calcined clay for sand a better burned body is produced, but the amount required to overcome the cracking is usually so large as to render the body too gritty, and unworkable in clay machinery.

THE PREHEATING METHOD.

This method seems to give good results. It consists in heating the raw clay in a rotary kiln to a temperature from 400

degrees to 600 degrees C., or a temperature that stops short of destroying all plasticity, which varies for different clays. This preliminary heating destroys the adhesive, pasty qualities of the clay, causes it to become somewhat granular in texture, and much easier to work and dry than in the raw state. This process seems to have been tried at a clay plant in Edmonton, and it is stated that the results were successful. The expense of the preheating treatment is the chief obstacle to its use.

EFFECT OF CHEMICAL COAGULANTS.

Highly plastic clays are affected in a marked degree by the addition of chemicals that coagulate and render them denser. A less amount of water is required to produce plasticity by the use of small amounts of these substances, hence the shrinkage is reduced and the drying hastened. Various coagulants were used in the investigation, including carbonate of soda, barium hydrate, hydrochloric acid; but the clays were only slightly affected by these chemicals and none of their objectionable features were overcome.

The only material of this class which proved of assistance was common salt. About 1 or 2 per cent of salt had the effect of keeping the surface of the moulded pieces moist while the body was drying. The drying qualities were improved by its use, but the working qualities were not.

EFFECT OF CAUSTIC LIME.

It has long been observed by the writer during the testing of a large number of western clays that the more calcareous ones generally gave less trouble in drying than the non-calcareous clays.

A series of tests were consequently made to determine the effect of the addition of various percentages of lime to those clays that cracked in drying. The only form in which lime was effective for this purpose was in the caustic state, generally known as quicklime.

Many of the clays described in this report are exceedingly plastic, and stiff and sticky when wet, so that they are difficult to work in any form of clay working machinery. These bad working qualities, when accompanied by defective drying, render t' 'm very undesirable for the manufacture of clay products.

The addition of 1 to 3 per cent of quicklime to these clays gives immediate relief, by destroying the stickiness, and causing an extraordinary difference in the ease with which they can be worked up. An excess of quicklime will make the wet body actually short and crumbling so that it would be liable to tear in moulding. The quantity of water required for tempering the clay is increased by the use of quicklime.

The effect of caustic lime on drying is even more pronounced than on the working qualities of the clay. Small test pieces that cracked badly when drying in a room, could be dried intact when exposed to warm sun and wind, when a small percentage of it was added. The quicklime should be finely ground and thoroughly mixed with the clay at least 24 hours before using for moulding.

The effect of caustic lime on the burned body is the weak point of the mixture. It causes a white scum on the surface of the burned ware, and weakens the body unless burned to a high temperature.

The experiments with this ingredient have not been carried far enough yet to make a full report on its effect on the various clays.

Clayworkers as a rule avoid lime if possible, as it is a detriment, especially when present in coarse particles. Its use in connexion with these troublesome clays is only advocated as a last resort, when other remedies have failed. One sample when burned showed no effect of the quicklime, except a somewhat lighter colour.

[illegible]

[illegible] katchewa[illegible] at [illegible]

EXPLANATION OF PLATE II

Section of Pleistocene [illegible] at Elliott's brick-yard, Saskatoon

Plate II

EXPLANATION OF PLATE III.

Stratified, stoneless, Pleistocene clay in pit of Canadian Clay Products Co., Floral, Saskatchewan

Plate III.

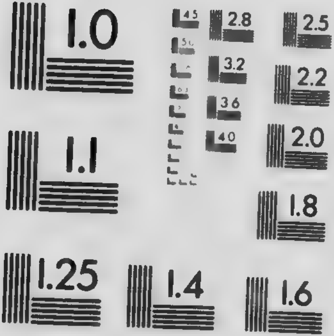
EXPLANATION OF PLATE IV.

Typical exposure of clay beds and lignite seams in Big Muddy River valley, Saskatchewan.

Plate IX

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



EXPLANATION OF PLATE V

A. Brick plant and clay pit, Innisfail Brick Co., at Innisfail, Alt.

B. Cutting in stratified Pleistocene clay, Canadian Northern railway, near Bullocksville, Alberta

PLATE X

A

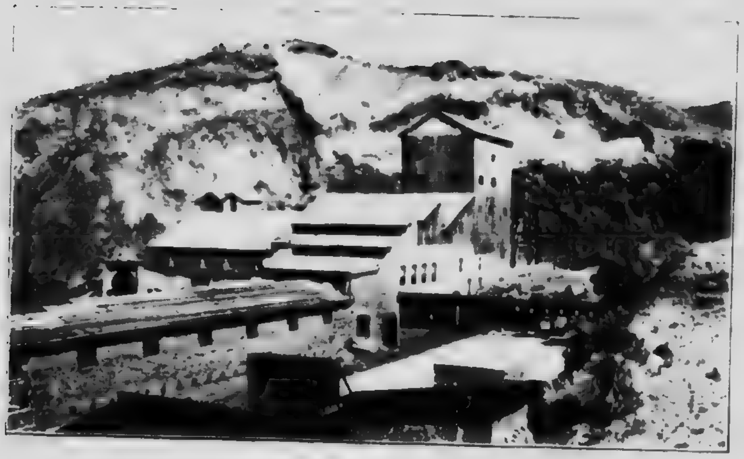
B

EXPLANATION OF PLATE VI.

A. Plant and clay bank of the Medicine Hat Brick company, Medicine Hat, Alberta.

B. Updraft case kilns, for burning common brick with natural gas at works of Medicine Hat Brick company.

PLATE XI



A

B

EXPLANATION OF PLATE VII

[illegible] shale deposits in Edmonton formation, near Nevis, Al[illegible]

B. Plant of the Medicine Hat Pottery company, Medicine Hat, Al[illegible]

PLATE VII

A

B

EXPLANATION OF PLATE VIII.

A. Shale and sandstone beds in the eastern escarpment of the Porcupine hills, southern Alberta.

B. View looking eastward towards Macleod, across drift-covered plain, from Porcupine hills, southern Alberta.

Plate VIII

A

B

INDEX.

A.

B.

C.

D.

I

LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY.

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers and, therefore, the following list has been prepared to prevent any misconceptions arising on this account. The titles of all other important publications of the Geological Survey are incorporated in this list.

Memoirs and Reports Published During 1910.

REPORTS.

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont.—by W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada—by R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories—by Joseph Keele. No. 1097.

Summary Report for the calendar year 1909. No. 1120.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario —by Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley mining district, British Columbia—by Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palæoniscid fishes from the Albert shales of New Brunswick—by Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory—by D. D. Cairnes.

MEMOIR 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *No. 6, Geological Series.* Geology of St. Bruno mountain, Province of Quebec—by John A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES.

MEMOIR 11. *No. 1, Topographical Series.* Triangulation and spirit levelling of Vancouver island, B.C., 1909—by R. H. Chapman.

Memoirs and Reports Published During 1911.

REPORTS.

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902—by Alfred W. G. Wilson. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers—by W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming—by Morley E. Wilson. No. 1064.

Summary Report for the calendar year 1910. No. 1170.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec—by W. J. Wilson.

Guide Book No. 2. Excursions in the Eastern Townships of Quebec and the eastern part of Ontario.

Guide Book No. 3. Excursions in the neighbourhood of Montreal and Ottawa.

Guide Book No. 4. Excursions in southwestern Ontario.

Guide Book No. 5. Excursions in the western peninsula of Ontario and Manitoulin island.

Guide Book No. 8. Toronto to Victoria and return *via* Canadian Pacific and Canadian Northern railways: parts 1, 2, and 3.

Guide Book No. 9. Toronto to Victoria and return *via* Canadian Pacific, Grand Trunk Pacific, and National Transcontinental railways.

Guide Book No. 10. Excursions in Northern British Columbia and Yukon Territory and along the north Pacific coast.

MEMOIRS—GEOLOGICAL SERIES

MEMOIR 17. *No. 28, Geological Series.* Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que.—by Morley E. Wilson.

MEMOIR 18. *No. 19, Geological Series.* Bathurst district, New Brunswick—by G. A. Young.

MEMOIR 26. *No. 34, Geological Series.* Geology and mineral deposits of the Tulameen district, B.C.—by C. Camsell.

MEMOIR 29. *No. 32, Geological Series.* Oil and gas prospects of the northwest provinces of Canada—by W. Malcolm.

MEMOIR 31. *No. 20, Geological Series.* Wheaton district, Yukon Territory—by D. D. Cairnes.

MEMOIR 33. *No. 30, Geological Series.* The geology of Gowganda Mining Division—by W. H. Collins.

MEMOIR 35. *No. 29, Geological Series.* Reconnaissance along the National Transcontinental railway in southern Quebec—by John A. Dresser.

MEMOIR 37. *No. 22, Geological Series.* Portions of Atlin district, B. C.—by D. D. Cairnes.

MEMOIR 38. *No. 31, Geological Series.* Geology of the North American Cordillera at the forty-ninth parallel, Parts I and II—by Reginald Aldworth Daly.

Memoirs and Reports Published During 1914.

REPORTS, ETC.

Summary Report for the calendar year 1912. No. 1305.

Museum Bulletins Nos. 2, 3, 4, 5, 7, and 8 contain articles Nos. 13 to 22 of the Geological Series of Museum Bulletins, article No. 2 of the Anthropological Series, and article No. 4 of the Biological Series of Museum Bulletins.

Prospector's Handbook No. 1: Notes on radium-bearing minerals—by Wyatt Malcolm.

MUSEUM GUIDE BOOKS.

The archæological collection from the southern interior of British Columbia—by Harlan I. Smith. No. 1290.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 23. *No. 23, Geological Series.* Geology of the coast and islands between the Strait of Georgia and Queen Charlotte sound, B.C.—by J. Austen Bancroft.

Memoir 25. *No. 21, Geological Series.* Report on the clay and shale deposits of the western provinces (Part III)—by Heinrich Ries and Joseph Keele.

Memoir 30. *No. 40, Geological Series.* The basins of Nelson and Churchill rivers—by William McInnes.

Memoir 20. *No. 41, Geological Series.* Gold fields of Nova Scotia—by W. Malcolm.

Memoir 36. *No. 33, Geological Series.* Geology of the Victoria and Saanich map-areas, Vancouver island, B.C.—by C. H. Clapp.

Memoir 52. *No. 42, Geological Series.* Geological notes to accompany map of Sheep River gas and oil field, Alberta—by D. B. Dowling.

Memoir 43. *No. 36, Geological Series.* St. Hilaire (Beloeil) and Rougemont mountains, Quebec—by J. J. O'Neill.

Memoir 44. *No. 37, Geological Series.* Clay and shale deposits of New Brunswick—by J. Keele.

Memoir 22. *No , Geological Series.* Preliminary report on the serpentines and associated rocks, in southern Quebec—by J. A. Dresser.

Memoir 32. *No. 25, Geological Series.* Portions of Portland Canal and Skeena Mining divisions, Skeena district, B.C.—by R. G McConnell.

Memoir 47. *No. 39, Geological Series.* Clay and shale deposits of the western provinces, Part III—by Heinrich Ries.

Memoir 40. *No. 24, Geological Series.* The Archæan geology of Rainy lake—by Andrew C. Lawson.

Memoir 19. *No. 26, Geological Series.* Geology of Mother Lode and Sunset mines, Boundary district, B.C.—by O. E. LeRoy.

Memoir 39. *No. 35, Geological Series.* Kewagama Lake map-area, Quebec—by M. E. Wilson.

Memoir 51. *No. 43, Geological Series.* Geology of the Nanaimo map-area—by C. H. Clapp.

Memoir 61. *No. 45, Geological Series.* Moose Mountain district, southern Alberta (second edition)—by D. D. Cairnes.

Memoir 41. *No. 38, Geological Series.* The "Fern Ledges" Carboniferous flora of St. John, New Brunswick—by Marie C. Stopes.

Memoir 53. *No. 44, Geological Series.* Coal fields of Manitoba, Saskatchewan, Alberta, and eastern British Columbia (revised edition)—by D. B. Dowling.

Memoir 55. *No. 46, Geological Series.* Geology of Field map-area, Alberta and British Columbia—by John A. Allan.

MEMOIRS—ANTHROPOLOGICAL SERIES.

Memoir 48. *No. 2, Anthropological Series.* Some myths and tales of the Ojibwa of southeastern Ontario—collected by Paul Radin.

Memoir 45. *No. 3, Anthropological Series.* The inviting-in feast of the Alaska Eskimo—by E. W. Hawkes.

Memoir 49. *No. 4, Anthropological Series.* Malecite tales—by W. H. Mechling.

Memoir 42. *No. 1, Anthropological Series.* The double curve motive in northeastern Algonkian art—by Frank G. Speck.

MEMOIRS—BIOLOGICAL SERIES.

Memoir 54. *No. 2, Biological Series.* Annotated list of flowering plants and ferns of Point Pelee, Ont., and neighbouring districts—by C. K. Dodge.

Memoirs and Reports Published During 1915.

MEMOIRS—GEOLOGICAL.

MEMOIR 58. *No. 48, Geological Series.* Texada island—by R. G. McConnell.
MEMOIR 60. *No. 47, Geological Series.* Arisaig-Antigonish district—by M. Y. Williams.

Memoirs and Reports in Press, January 20, 1915.

MEMOIR 50. *No. 51, Geological Series.* Upper White River district, Yukon —by D. D. Cairnes.

MEMOIR 56. *No. 56, Geological Series.* Geology of Franklin Mining camp, B.C.—by Chas. W. Drysdale.

MEMOIR 62. *No. 5, Anthropological Series.* Abnormal types of speech in Nootka—by E. Sapir.

MEMOIR 63. *No. 6, Anthropological Series.* Noun reduplication in Comox, a Salish language of Vancouver island—by E. Sapir.

MEMOIR 46. *No. 7, Anthropological Series.* Classification of Iroquoian radicals with subjective pronominal prefixes — by C. M. Barbeau.

MEMOIR 59. *No. 55, Geological Series.* Coal fields and coal resources of Canada—by D. B. Dowling.

MEMOIR 67. *No. 49, Geological Series.* The Yukon-Alaska Boundary between Porcupine and Yukon rivers—by D. D. Cairnes.

MEMOIR 57. *No. 50, Geological Series.* Corundum, its occurrence, distribution, exploitation, and uses—by A. F Barlow.

MEMOIR 64. *No. 52, Geological Series.* Preliminary report on the clay and shale deposits of the province of Quebec—by J. Keele.

MEMOIR 65. *No. 53, Geological Series.* Clay and shale deposits of the western provinces, Part IV—by H. Ries.

MEMOIR 66. *No. 54, Geological Series.* Clay and shale deposits of the western provinces, Part V—by J. Keele.

MEMOIR 70. *No. 8, Anthropological Series.* Family hunting territories and social life of the various Algonkian bands of the Ottawa valley—by F. G. Speck.

MEMOIR 71. *No. 9, Anthropological Series.* Myths and folk-lore of the Timiskaming Algonquin and Timagami Ojibwa—by F. G. Speck.

MEMOIR 69. No. 57, *Geological Series.* Coal fields of British Columbia—by D. B. Dowling.

MEMOIR 34. *No. , Geological Series.* The Devonian of southwestern Ontario and a chapter on the Monroe formation—by C. R. Stauffer.

MEMOIR 73. *No. , Geological Series.* The Pleistocene and Recent deposits of the Island of Montreal—by J. Stansfield.

Summary Report for the calendar year 1913.